Integrated Turf Health Management Plan for the Hills Golf Course East Quogue, Southampton, NY

Prepared for DLV Quogue, LLC

EQGC
PO Box 244
East Quogue, NY 11942
jlscoast@optonline.net
Preparer: Jeffrey L. Seeman

11/11/2014

Table of Contents

Abbreviations

BMP	Best Management Practices
CEC	Cation Exchange Capacity
CGA	Compatible Growth Area
EIFG	Environmental Institute for Golf
EPA	United States Environmental Protection Agency
GCSAA	Golf Course Superintendent Association of America
IPM	Integrated Pest Management
LICPB	Long Island Central Pine Barrens
MCL	Maximum Contaminant Level
MGD	Million Gallons per Day
Mg/L	Milligrams per liter (parts per million)
N	Nitrogen
NH_4^+	Ammonium (positive ionic charge)
(NH_2) 2CO)	Urea (neutral ionic charge)
NO_3^-	Nitrate (negative ionic charge)
NTEP	National Turf Evaluation Program
NVDI	Normalized Difference Vegetation Index
NYSDEC	New York State Department of Environmental Conservation
ppm	Parts per million
SCDOH	Suffolk County (NY) Department of Health Services
USGA	United States Golf Association
USGS	United States Geological Survey

Executive Summary

This analysis is conducted for the purpose of identifying golf course management and operational procedures to minimize or avoid potential adverse environmental impacts from the golf course proposed as a component of the Hills MUPDD, East Quogue, Town of Southampton, New York. Summarized below are commitments offered by the applicants, who shall:

- **Design and Manage the Golf Course in Accordance with <u>Best Management Practices for New York State Golf Courses</u>, (BMPNYS) February, 2014:**

In response to the Town of Southampton's requirement to provide an Integrated Turf Health Management Plan, the Hills' applicants propose the golf course design and management will meet or exceed the <u>Best Management Practices for New York State Golf Courses</u> (NYSBMP). The BMP was developed with Cornell University, New York State's golf course superintendents, the NYSDEC and other stakeholders. It is a new State standard for turf management practices, designed to protect natural resources, with an emphasis on water quality. The BMP is a decision making tool with post decision monitoring, conducted to evaluate and adjust applied turf management strategies. The course final design, construction, and operations will meet the BMP principals and additional healthy turf management strategies. The Hills will exemplify environmental stewardship, and coexist with other forms of land uses without negative impacts to the environment.

- **Implement an Integrated Turf Health Management Plan (ITHMP)**

The ITHM approach uses plant health science based technologies coupled with an Integrated Pest Management (IPM) program. The basis of ITHM protocol is to *manage healthy turf* by using science, technological resources and cultivation practices to grow healthy turfgrass. Healthy dense turf is the cornerstone of minimizing inputs. The applicants will implement the ITHM program as an effective management tool to minimize inputs, thereby reducing potential impacts. The ITHM program is implemented through course design; soil design; irrigation system; turf equipment; support technologies; proper turf types; daily scouting for pests and turf conditions, monitoring pest thresholds; laboratory based disease/pest identification; recordkeeping and monitoring; timing and characteristics of selected and applied fertilizers and pesticides. All are factors and tools to be used by the Hills to accomplish the goal of minimizing impacts. The applicant's turf managers will promote healthy turf with improved soil health (maintaining types and quantities of microbes; maintaining adequate oxygen; sustaining correct water retention and organic matter, etc.). Management will improve the surface conditions for turf health by managing shade, improving air circulation, controlling light exposure and minimizing wear. Decision making within the ITHM approach gives priority to cultural practices and natural methods of turf care. The applicants will analyze the soil for physical, chemical and microbial properties prior to the final design of the project, to determine soil conditions with respect to the selected turf species. The applicants will refine the ITHM plan during the golf course's final design, and implement the practices during construction and long term operation of the course.

- **Develop Ground and Surface Water Monitoring Protocols (G&SWMP):**

With input from the Town of Southampton, the Hills will participate in a voluntary program to provide technical expertise and funding to develop Ground and Surface Water Monitoring Protocols (G&SWMP), to demonstrate how the Hills' inputs and turf management influence local water quality. The monitoring program will incorporate groundwater monitoring wells, lysimeters and surface water sampling locations to identify impacts of the development on the local surface and groundwater. Baseline monitoring will begin prior to construction to establish existing condition criteria against which post development data will be compared. Sampling points will be located to identify upstream conditions, impacts of golf course turf maintenance, and impacts from onsite septic systems as part of the housing component of the development. The Hills in cooperation with the Town will establish reasonable threshold limits for prescribed pesticides and nutrient analytes. These limits will act as "triggers" and elicit immediate response by the Hills (resampling and/or turf management responses) to address exceedances. The program will be used to evaluate the actual post construction impact of applied pesticides and nutrients. The threshold limits, determined with stakeholder technical input are science based, applied to select compounds, and are used to adjustment turf management. These limits will be used to provide continuous feedback as to the efficiency of fertilizer and pesticide applications to minimize environmental impacts and maximize turf health. Southampton has requested similar post construction quarterly water quality monitoring at golf courses, specifically at Sebonack Club and Golf at The Bridge. The Hills and the Bridge have approximately the same areas of managed turf. The total allowable fertilized/input managed area of the Bridge is 80.38 acres and the proposed Hills golf course managed turf area is approximately 82 acres; and the Bridge serves as a reasonable model for the expected water quality impacts from the Hills. These existing developments comply with water monitoring protocols through an agreement between the Town and course developer/owners. The G&SWMP must consider existing conditions and future local ground and surface water quality impact potential generated through up-gradient land use, agricultural runoff, and area wide sanitary discharges. The background water quality data will require careful evaluation to establish the parameters for the monitoring program and the thresholds for the concentration of compounds (triggers) and potential sources. The anticipated G&SWMP will involve installation of groundwater monitoring wells (couplets), suction lysimeters, sampling points at Weesuck Creek, and possibly coordination with other involved agencies (SCDOH, NYSDEC).

The G&SWMP will be provided as a separate document that details the location and construction of the lysimeters and groundwater and surface water monitoring points. These details will ensure that the sampling locations provide samples that are representative of actual conditions and are not subject to inadvertent contamination. QA/QC procedures for sampling and laboratory analysis will also be detailed. The sampling parameters will also be identified for nutrients and pesticides. A list of acceptable pesticides that may be used on the site will be provided. Other pesticides would not be used without agreement by the town.

- **Utilize Bio-Filters to Reduce Sediment and Stormwater Generated Pollutants:**

Where practicable (determined by topography, clearing limits, and peak flow analyses) stormwater from the golf course will be pre-treated using bio-filters (grassed swales; small constructed wetlands) prior to discharge to the detention pond or leaching pools. The bio-filters will collect and retain sediment and absorb nutrients from the stormwater before it reaches the detention pond and/or leaching pools.

- **Install HDPE Synthetic Liners Below the Greens:**

The golf course greens areas typically require the most intensive inputs. Together with the ITHM and G&SWMP, the applicant's environmental design feature includes placement of liners below the USGA constructed greens. Each drainage layer beneath the greens will be isolated from the native subsoil by placement of an impermeable (HDPE) synthetic liner, which serves as a barrier and prevent conveyance of recharged water from the green areas. The system will capture water percolating through the green's soil profile and drainage layer, and direct the flow through a closed collection system. The liner and greens drainage design will be consistent with other golf course green designs utilized within Southampton (i.e. Sebonack Golf Club). The liner systems have proven to be an effective measure to avoid potential adverse groundwater impacts. Groundwater monitoring and reporting will be used as a metric for the ITHM practices and the liners will provide additional assurance of groundwater quality protection.

- **Collect & Recycle On Site Stormwater Runoff:**

The site's proposed infrastructure provides a stormwater collection system that will route the majority of the surface runoff to an impermeable (lined) 3.8 acre detention pond. This reservoir of stormwater will include a floating treatment wetland to improve pond water quality. The pond will receive additional clean water from the onsite irrigation supply well. The stormwater will be recycled as supplemental irrigation water for the golf course, as water is withdrawn from the pond.

- **Voluntary Participation in and Compliance with the Standards of The Peconic Estuary Nitrogen Management Challenge for Golf Courses:**

This voluntary program was developed with Cornell University, USEPA, Peconic Estuary Program stakeholders, SCDOH, USGA, and local east end golf course superintendents. The program limits the long term average nitrate in groundwater to $\leq$ 2.0 ppm; well below the New York and Federal Standard for drinking water of 10 ppm.

- **Utilize State of the Art Irrigation Control Systems:**

Golf course irrigation systems today use computer controlled irrigation sprinklers and drip irrigation that are managed by in-ground soil moisture meters and above ground weather stations. These technologies maintain soil moisture levels near field capacity. High efficiency electric variable frequency drive (VFD) pumps and individual sprinkler head controls allow water to be applied where and when it is required, without sequencing of entire zones. This reduces over and under watering which can decrease plant health, increase stress and disease pressure, and hold potential for pesticide and nutrient runoff and leaching concerns. The system reduces the watering time, minimizes and conserves water resources. When necessary wetting agents will be used to reduce water inputs and improve water dispersion to the root zone.

- **Develop Cultural Practices for Promoting Turf Health**

The selected turfgrass management practices will include implementing a schedule of cultivation to promote healthy turf and improved soil conditions. The program includes aerification with topdressing soil (sand/soil/peat) as prescribed by physical soil tests; aerification to relieve compaction and to improve drainage and soil gas exchange; verti-cutting to remove excessive thatch (organic matter); drill and fill (deep soil coring to improve soil conditions); mowing height adjustments to relieve turfgrass wear and stress. Cultivation will be used to improve air circulation and provide proper soil moisture throughout the course.

- **Utilize State of the Art Equipment and Resources and Trained Personnel for Turf Management**

The turf industry offers improved technologies for equipment and continuing education programs for its industry members. Hybrid fairway mowers and battery powered hand green mowers have significantly improved energy conservation goals and reduced the golf industry's fossil fuel use. Powered turf boom sprayer with spray nozzle boom curtain with GIS application system and computerized application controls (designed to specifically apply inputs within the GIS mapped areas and direct nozzle spray downward with zero to minimal drift potential). Turf management facilities are equipped with emergency response and spill cleanup kits, trained personnel, wash down and wastewater recycling equipment; fuel and chemical storage and handling equipment that exceeds the minimum standards for SCDOH and NYSDEC. Experiments with drones for scouting and monitoring nighttime turf conditions use video cameras to assess irrigation coverage and disease outbreaks in the absence of the superintendent's staff. Global Positioning Systems (GPS) are used to delineate the limits of each turf area (tees, greens, fairways and roughs). Each area is programed into the turf sprayer on board computer. The system minimizes unintentional applicator error, (over and under sprays) and conserves inputs by treating only areas of specific need. Mowers and irrigation system controls can be connected to this overall computerized GPS- turf management system. Turf and soil samples will be routinely collected and analyzed by qualified laboratories to determine nutrient levels, plant physiological conditions, physical properties of soils and turf pathogen identification.

- **Operate and Maintain a Sustainable Golf Course Facility**

Today's professional golf facility management is based on sustainability. Clubhouse menus are designed around local food sources and season availability. Clubs often grow their own herbs and vegetables, install solar panels to recharge batteries in electric golf carts and turf equipment, and supply heated water for pools, showers and buildings. Several facilities recycle their kitchen and golf course organic waste for compost, compost teas, topdressing and landscape garden mulch. Integrated with these programs are ornamental gardens with selected plants to attract and maintain populations of butterflies, bees, and hummingbirds and bluebird, bat, purple martin, and wood duck houses are often installed throughout the course. Ponds can be stocked with trout from local fish hatcheries. Sustainability reduces operating costs and provides users a connection to the local environment.

- **Provide Public Outreach Programs for Turf Management**

Turf and ornamental plantings are mainstays of local residential properties. The Hills will offer its professional and technical support to the local community. Using website communications and local presentations the Hills will educate the community on how to improve turf health and its quality with minimal inputs to protect water quality.

Introduction

This analysis is conducted for the purpose of identifying golf course management and operational procedures to minimize or avoid potential adverse environmental impacts from the proposed Hills Golf Course, East Quogue, Town of Southampton, Long Island, New York. Among the Top 100 Golf Courses in America listed by Golf Digest, eight (8) are on Long Island and six (6) of these are located in eastern Suffolk County: National Golf Links of America, Shinnecock Hills, and Sebonack Golf Club in Southampton; Maidstone, in East Hampton; Fishers Island, Town of Southold; and Friar's Head located in Riverhead. Long Island golf courses have hosted the national championships for men and women, PGA and LPGA tournament events, offer recreational golfers opportunity for play, and support local recreational based economies. The well drained, sandy soils and excellent water quality of Long Island offer superior conditions for the design and construction of world class golf facilities.

In response to the Town of Southampton's request to provide an ITHM plan, the Hills' applicants propose to design and manage the golf course in accordance with the NYSBMP (Appendix 1). The document, released in February 2014[1]. The NYSBMP is "the tool" by which all golf courses in New York are to be managed to maximize environmental stewardship, regulatory compliance, and successful turf management.

In addition to the NYSBMP the applicants propose to develop a site specific Integrated Pest Management program (IPM) and ITHM plans that will be presented in more detail during the final design and construction phases of the golf course. Each of these programs (IPM and ITHM) are offered herewith as preformats until specific turf pest and disease thresholds are established, soil sampling and analytical results of soil properties and chemistry can be established for critical turf areas, and vegetation clearing lines have been refined. A foundation of the IPM and ITHM programs are based on using industry trained golf course personnel to provide daily scouting, monitoring, recordkeeping, and decision making in response to the maintenance of healthy turf.

The Town of Southampton has requested two prior golf course development projects to develop IPM/ITHM for turf management and required post construction environmental monitoring programs as conditions of the Town's planning and permitting processes. Included in these requests were groundwater sampling programs utilized to verify impact from turf management programs; and IPM/ITHM and biological improvements to soils as efforts for the applicants to reduce inputs and avoid or minimize negative impacts, particularly impacts to ground and surface water qualities. The results of the groundwater monitoring programs have indicated there is no significant impact on water quality as a result of professionally managed golf course developments and operations (Petrovic). The Hills project will also establish baseline water quality data from shallow and deep groundwater wells and continue to conduct

[1] Authored by: Robert E. Portmess PhD, Department of Horticulture, Cornell University; Jennifer A. Grant PhD, New York State Integrated Pest Management Program, Cornell University; Barry Jordan, RLA, Golf Course Architect; Anthony M. Petrovic PhD, Department of Horticulture, Cornell University; Frank S. Rossi PhD, Department of Horticulture, Cornell University

groundwater monitoring post golf course construction. The groundwater sampling points will be determined with the Town of Southampton and, at a minimum, provide

- up-gradient and down-gradient well clusters;
- groundwater monitoring well installation methods (i.e. Geo-Probe with soil sample cores at a predetermined interval),
- a list of compounds for analyses;
- protocols for QA/QC water sample collection, preservation and lab work;
- lysimeter installations at key locations for upper surface level sampling points;

The frequency of the sampling program (quarterly or less frequently) and recordkeeping of the results will be also need to be determined. Maximum limits for select compounds will be established and used as "triggers" to determine appropriate management responses when limits are exceeded.

The two previously constructed golf course projects, Golf at the Bridge (the Bridge) and Sebonack Golf Club (Sebonack) serve as a demonstration, and as validation to the mitigation measures proposed in each project's environmental impact statement. Each golf course has served as a "living laboratory" for understanding turf management practices relevant to golf course management within Southampton and examples of turf management impacts on the environment. The post construction water quality data agree with findings from university research conducted on turf management practices and environmental impact since the 1980s.

The current philosophies and practice of professional turf management are directed toward a sustainable environment and development of "healthy turf." The elemental idea is, healthy turf will defend itself against biotic and abiotic influences. The ITHM will evaluate the soil organic and inorganic chemistries and physical properties to determine what compost, soil amendments and microbial levels are necessary to improve soil quality for turfgrass. The dominant site soil series types are Carver, Plymouth, and Riverhead with occasional areas of Haven. For these soils fertility and moisture holding capacities is generally low.[2]

The breeding of turfgrass cultivar has advanced significantly in the past decade. Breeders are capable of combining genetic advantages of turf species and sometimes across genus to selectively introduce cultivars with disease resistance, low growth heights, high densities, color, drought tolerance, and low fertility demands. Furthermore blending cultivars has become more widely accepted by the industry rather than cultivating a mono-culture. Mono-cultures were popular because each offered a "pure" stand of turf and provided a uniform conditions for playing golf (hence truly a level playing field). However, pathogenic genetic re-combinations tend to selectively cull out the most advantageous populations of pests that can overcome disease resistant turf species in stands of mono-cultures with often dramatic effect. One example is perennial rye grass, used on fairways for its general resistance to wear, good color, rapid germination and low production of thatch. However many rye grass cultivars planted as fairways were susceptible to gray leaf spot, a pathogenic disease which can quickly kill large areas of turf in 24 to 36 hours.

---

[2] USDA/SCS, Soil Survey of Suffolk County, April, 1975.

To minimize inputs and sustain a healthy, high quality playing surface, the Hills will continue to research the selection of turf grasses most suited for the existing environmental conditions of the site and species that require low inputs. One blend that matches these qualities for fairway use is a combination of colonial bentgrass (*Argrostis capillaris* L.) (Tiger 2) and chewing fescues (*Festuca rubra* L. ssp *comutata*) (Longfellow II), and each can tolerate low (0.500-inches) mowing heights. A research article on this blend is included in Appendix 2. Although greens typically require more intense management, fairways occupy 20 times the area of greens, and a greater reduction of inputs on fairways can have a significant effect on overall turf management. Fairways are typically constructed from native soils with amendments added as determined from soil analyses of physical and chemical properties.

Greens will be constructed in accordance with USGA recommended specifications that identify limits of soil physical properties based on particle size distribution for root zone mixes (Appendix 3). The HDPE impermeable liners and drainage collection system will be installed beneath the green's gravel layer and the native sub-soil. The liner system will capture all of the water and residual inputs within the green area and prevent the solutes form recharging to groundwater. The USGA recommended saturated hydraulic conductivity of the green's root zone mix is a minimum of 6-iches per hour. Studies on green construction using one hundred percent sand based greens have been shown to increase the nutrient leaching potential. The USGA standards for green construction recommends adding organic matter, which studies have shown to reduce input leaching potential. A typical "dirty-sand" mix is "85-5-10" consisting of 85 percent sands and 5 percent soil and 10 percent organic matter (peat)[3]. Dollar spot is a common and persistent turf disease on Long Island. Disease resistant bent grass cultivars (such as "Declaration" and "Proclamation") help to reduce fungicide inputs used in response to dollar spot. Cultivation practices including verti-cutting, top dressing (with a 90-10 mix) daily rolling and removal of guttation have been proven to be highly effective methods to control dollar spot without the need for chemical inputs. Regardless of the method of management selected for disease and pest controls, the Hills use of the greens subsurface liners will avoid potential impacts to groundwater, even if a misapplication of inputs to the greens occurs (i.e. inputs were applied prior to an unpredicted weather event).

For fairway, tee and rough construction, Landschoot provides recommendations for additions of compost to improve soil conditions to support turfs (Appendix 4). Compost sources and quality must be carefully selected and samples tested to establish qualitative characteristics.[4] Biotic inoculants (fungal and bacteria species) are necessary for supporting soil in the ITHM program. Suggested microbial levels for turfgrass species and mixes was provided in the EIS prepared for the Bayberry Project (Sebonack Golf Club) and is shown in Table 9.

Long Island's general geology is dominated by glacial till, comprised of gravel and sandy soils; and its public drinking water supply is from the sole source aquifer that is situated beneath the Island. The NYS Drinking Water Standards has allowed a maximum contaminant level (MCL) of nitrogen (N) of 10 mg/L to protect human health and the environment. University

[3] USGA, Recommendations for a Method of Putting Green Construction

[4] Landschoot, P., Using Compost to Improve Turf Performance, Penn State Extension.

research conducted by marine scientists indicate a MCL of < 6.0 mg/L for N is suggested to protect marine resources. On Long Island, the source of increased concentration of N in the local surface water is groundwater outflow discharge to the Island's bays[5]. Sanitary systems, especially residential systems installed in close proximity to the shoreline are a primary source of N however, N leaching and runoff from golf courses has again come into view as a potential source for N impacts to groundwater quality within Suffolk County, NY.

The Hills approach to address potential impacts included review of scientific literature pertaining to golf turf management practices and environmental impact. The research identified methods and historical records used to assess the significance of turf management on water quality; identified the best management programs developed for New York State golf courses most applicable to the Hills golf course; and provided golf course development engineering controls to monitor and reduce potential for turf chemical releases to the environment. The following narrative provides management guidelines for turf managers to minimize potential leaching and runoff of nitrates, nutrients and other turf inputs; appropriate monitoring for pest control; techniques to improve turf health and performance; and recommends establishing thresholds for pest populations and or turf damage to balance acceptable playing conditions coupled with appropriate pest control responses designed to protect the ground and surface waters.

The Hills golf course turf management strategies include: soil and tissue testing as measures for assessing the nutrient status of turf; monitoring clipping yield to assess turfgrass growth and density; control of thatch and mat accumulation; water quality monitoring of groundwater and ponds, streams, or other water bodies for determining if runoff and leaching are occurring; lysimeter installation as sample collection points; moisture metering and advanced irrigation system design and controls for improved water conservation and irrigated area controls; use of cultural practices to reduce turf stress and disease pressure; and impact potential from variations in the formulation of supplemental nutrients, and species of turf grasses selected.

The golf course will occupy approximately 98.13 of which 78 acres will be managed with inputs and the balance comprised of bunkers, native plantings, ponds, and a maintenance areas. The site is subjected to the Long Island Central Pine Barrens (LICPB) core and compatible growth area (CGA) land use regulations where no more than 15% of the entire development project may include "fertilizer dependent vegetation."

The Pine Barrens legislation reduces the overall (nitrogen) inputs throughout the CGA. This restriction is significant when estimating the overall nitrogen loads generated by the project's nutrient programs. Methods to estimate nitrogen loading were developed by the USEPA, USGA, Peconic Estuary Program stakeholders and Eastern Long Island golf course superintendents in a program called the "East End Nitrogen Reduction Program for Golf Courses." This program has been in place for more than a decade, has specifically targeted a reduction of golf course generated nitrogen limited to 2.0 mg/L, is still active and administered by Cornell Cooperative Extension. Cornell calculates the nitrogen loading from participating golf courses by using the quantity (expressed in pounds) of applied nitrogen to the area of fertilized as

[5] Gobler, C. "Is There a Connection Between Groundwater Seepage and Brown Tide In Long Island Embayments?"

well as unfertilized land within the entire golf property boundaries (expressed in square feet or acres). Therefore, when nitrogen applications are measured as a mass per unit of area the potential of nitrogen loading from properly managed turf within the CGA is expected to be much less than managed turf in areas of Suffolk County where 100 % of the development project can establish fertilizer dependent vegetation.

There are clearing limit restrictions for any proposed development within the boundaries of the CGA. The clearing is necessary for the golf course, stormwater control/irrigation pond, maintenance facility, clubhouse and golf related infrastructure. Relevant Pine Barren policies are included as Appendix 5.

The industry has developed selected blends and many turf cultivars that do not require significant amounts of inputs including nitrogen. With early planning, design and selection of the most appropriate turfgrasses, a further reduction in predictive supplemental nitrogen and inputs is expected. Coupled with the selection of cultivars and a mandatory reduction in overall fertilized vegetation required within the CGA, the selection of turf cultivars will be based on drought tolerance and low water inputs. The turf industry has responded to the need to conserve water resources by breeding turf grasses for golf courses that require less water. Again using the mix example of colonial bentgrass and chewing fescues; fescues are highly desirable for resistance to drought conditions, "green-up" best in cool (spring and fall) conditions and are a bunch-type grass; and colonial bentgrasses tolerate higher temperatures (summer), increase density by growth via stolons, produce less thatch due to growth habits; are less aggressive than creeping bentgrass, and are moderately drought tolerant. Each is highly wear resistant, exhibits good disease resistance, and requires well drained low fertility soils.[6] Selecting a blend of cultivars that are most adaptable to the existing site specific environmental conditions provides a sustainable approach to turf management. The turfs selected become an eco-tone within the dominant surrounding ecology rather than an overly demanding, unwanted "step-child." The playing surfaces (tees, greens, fairways and primary roughs) transition out to the secondary roughs (comprised of native planted species), and finally the indigenous native vegetation. This "organic" course design is advocated by the USGA to emphasize sustainable golf course management; improved golfer connection to the natural environment; and conservation of resources.

Grasses are part of the Pine Barrens ecology, and introduction of the grass cultivars for golf turf and secondary roughs must closely reflect the successful qualities of these native grass species. This would tend to minimize environmental impact, reduce management inputs, and reduce turf management operational costs. The applicants will continue to work with cool season turf breeders and university researchers from Cornell, Rutgers, Ohio State and Penn State to select the most appropriate cultivars primarily for the fairways, as the fairways will comprise the largest areas of managed turf within the golf course boundaries. Inputs of irrigation water, mowing, turf nutrients and pesticides would not extend beyond the primary roughs to avoid disrupting the native vegetation and minimizing potential to cause other plant species to become competitive.

[6] Horgan, et al, "Fine fescues and Colonial Bentgrasses for Fairways," Environmental Institute for Golf.

During the past decade there have been significant developments in the turf industry in response to the reduction of inputs. These include improving native soil conditions by adding composts and microbe inoculations, new turf varieties derived through the sciences of plant genetics and breeding; online websites for monitoring and predicting local disease outbreaks driven by environmental conditions (temperature, humidity, etc.); guidance from the USGA to develop and manage courses using less natural resources; regulatory actions; and a greater separation between scientific models and researcher understanding of turfgrass and agricultural crop science. It is significant to understand that past research on crops such as wheat was historically used as the "model" for determining impacts, symptoms and curative/preventative controls for turfgrasses. This has changed. Turf science has evolved as an independent science within agricultural science and the older models. The understanding of treatment of disease and pests affecting turfgrass has been greatly improved. Maintaining the overall nutrient balance is still essential to optimal plant health.

The results from nine (9) years of groundwater monitoring studies at the Bridge in Bridgehampton, NY has provided the Town of Southampton with results on nitrogen and pesticide fate from golf courses. The Bridge was requested to monitor groundwater as a post construction condition of its approval. The facility has nine (9) groundwater monitoring wells and one (1) background groundwater well. The wells are used for water sampling and analyses to determine the course's nutrient and pesticide concentration impact to local groundwater. Lysimeters are also used as collection points and as early warning sample locations. The long term average goal for nitrate in groundwater is limited to 2.0 mg/L. To achieve these goals the Bridge is limited to a total nitrogen fertilizer application rate of 3000 pounds per year or the equivalent of 0.9 lbs. N/1000 SF (based on total property land area) (Appendix 6).

The Bridge's groundwater monitoring program includes analyses for pesticides. The 2011 technical review found the, "the overall quality of the groundwater has not been significantly affected by the golf course pest management operations at the Bridge golf course."[7] The report also evaluated the course's use of bio-fungicides and recommended evaluation of additional fungicides rated as "Low Risk" by the USEPA (Appendix 7). The 2013 report resulted in the same conclusion of the Bridge having no impact to groundwater (Petrovic).

Similar water monitoring programs conducted at Sebonack Golf Club indicate local water quality was not significantly impacted by the golf course operations (Petrovic 2014).

New York State Best Management Plan for Golf Courses

In February 2014 Cornell released the NYSBMP for Golf Courses. The document is a guidance/standards of practice document for managing golf turf and facilities. It offers information within the following categories:

---

[7] Petrovic & Cambareri, Technical Review of Test Results and Implementation of the Groundwater Monitoring Protocol the Bridge Golf Course, Southampton, NY Part 1 and Review of Protocols Modification Proposals and Recommendations Part 2, April 18, 2011.

- Environmental Concepts
- Water Quality Management
- Site Analysis and Water Quality Protection
- Irrigation
- Nutrient Management
- Cultural Practices
- Integrated Pest Management
- Pesticide Storage and Handling and Applications
- Maintenance Facilities

A summary of key points from the NYSBMP are quoted below. The complete BMP is contained in Appendix 1.

"Golf courses rely on a healthy environment that includes water and wildlife. It is of paramount importance to enhance and protect water quality. A significant body of research exists that indicates successful implementation of BMPs virtually eliminates the golf course risk to water quality. In fact, several studies have shown that implementing BMPs enhances water quality on its journey on and through the golf course property.

Additional incentives for golf courses in New York State to implement BMPs include the following:

- potential for more efficiently allocating resources by identifying management zones
- cost savings associated with applying less fertilizer and pesticide
- improved community relations
- recognition by club members and the community at large as environmental stewards

Through a cooperative approach between the golf industry and friends and neighbors outside the industry, practices have been developed that benefit all parties. Golf course BMPs are designed to minimize the transport of potential water quality contaminants (such as nitrogen and phosphorus) from the golf course into surface waters and groundwater. A decade of public and privately funded research concerning the fate of fertilizers and pesticides applied to turf has concluded that golf courses using BMPs pose little to no risk of contributing to water pollution. Specifically, several studies investigated the movement of nutrients and pesticides through the perennial turfgrass system and found that maintaining a dense, vigorous turf, identifying environmentally sensitive areas, and recognizing potential risks of certain soils and climatic conditions are essential to protecting water quality.

Regulatory compliance is the first step in aligning golf course management with BMPs. New York has some of the nation's strictest state regulations on pesticides and fertilizers. Golf course superintendents must be aware not only of regulations on the purchase, storage, handling, and application of fertilizers and pesticides, but also of the potential water quality contaminants, sources, and impacts associated with these compounds.

The next step in successful BMP implementation is to recognize the many management decisions that involve potential contamination of surface waters and groundwater and address course management practices in a systematic fashion. Once course management becomes aligned with regulations and water quality protection BMPs, additional value can be gained by using water quality monitoring as a final step to assess the actual water quality entering and leaving the course."

It is easy to understand the importance of the NYSBMP to turf managers and the community of stakeholders. Designing the golf course and constructing the facilities within the frame work of the NYSBMP leads directly to predetermining its turf management. Once approved, the Hills course may be among the first golf courses in New York to have been designed and constructed using the NYSBMP as a guide.

The Hills' 98.13-acre golf course component is distributed in the northern, southern and eastern portions of the South Parcel. The golf course is proposed to be an 18-hole, Par-71, Championship-grade facility with 78 acres or irrigated/fertilized turfs, a 0.5-acre maintenance area, and a 3.8-acre irrigation pond/pond house area affecting play on two holes. The Clubhouse area will occupy a separate 2.8 acres. The course will be designed to incorporate the site's existing rolling topography as much as practicable, thereby minimizing the acreage of land clearing and volume of soil affected by grading. The majority of the site's natural vegetation will be retained, to act as a visual and noise buffer between fairways, and between the site and its neighbors. As illustrated in the imagery, as well as on the Master Plan (South Parcel), fairways are narrow, adjacent "rough" areas are limited, and greens and tees occupy small areas of the golf play area. There are areas where "playover" is a design feature of the course. These areas involve retaining existing topography and groundcover vegetation in the alignment of the ball track, but golfers would "playover" the natural areas. In these areas, trees would be removed; however, the remaining natural habitat will be enhanced and restored and topography would be retained. All efforts have been made to design the course such that it has the least environmental impact and the greatest habitat retention possible.

The Clubhouse would have a total floor area of about 53,705 SF (divided into 29,705 SF of Clubhouse facilities and 24,000 SF in the 10 Clubhouse Units), with below-grade parking. This structure would have a complement of amenities typical of such a feature, and include men's and women's lockers, a dining room, lounge, spa and pool area. The clubhouse will not be available for public use; its facilities will be reserved exclusively for the use of the residents of the project.

Stormwater Management System

In conformance with Southampton Town Code, stormwater runoff generated from the proposed project will be retained on-site and recharged to groundwater. The drainage system will be designed for storage of stormwater generated from an appropriate rainfall event, as determined by the Town. It is anticipated that subsurface leaching pools will be used for containment and recharge of stormwater; however, fully engineered site plans (grading and drainage) have not yet been prepared. Innovative stormwater handling methods may be incorporated where appropriate and feasible. The systems will be designed to comply with General Permit for Stormwater Discharges from Construction Activity (GP 0-10-001 or "General Permit") and Chapter 285 of the Town Code. Under these requirements, a site-specific Stormwater Pollution Prevention Plan (SWPPP) must be prepared and submitted to the Town for review and approval as a condition to final subdivision approval. The SWPPP evaluates the proposed drainage system to ensure that it meets the NYSDEC and Town requirements for treatment and retention of stormwater runoff. The SWPPP must demonstrate that the proposed stormwater management system is sized adequately to ensure that there is no net increase in peak stormwater discharges from a property once developed.

Additionally, the SWPPP will include details of erosion controls to be employed during construction to contain stormwater runoff on site during construction and ensure that there is no transport of sediment off site. The Erosion Control Plan will be prepared in accordance with the recommendations of the NYSDEC Standards and Specifications for Erosion and Sedimentation Control and the NYSDEC Technical Guidance Manual. SWPPP measures include:

- Silt fencing and temporary diversion swales installed along the perimeter of the limits of clearing within the site to minimize/prevent sediment from washing into the natural buffer areas, adjacent streets and properties.
- Inlet protection installed around all grated drainage inlets to trap sediments in stormwater runoff.
- Dust control and watering plan and a stabilized construction entrance to minimize the tracking of dirt and debris from construction vehicles onto adjacent roadways.
- Designation of material and topsoil stockpile areas as well as use of silt fencing and anchored tarps to prevent/reduce wind-blown dust and erosion from rainwater.
- Establishment of a stabilized stone vehicle washing station which drains into an approved sediment-trapping device.

The proposed locations, sizes, and lengths of each of the temporary erosion and sediment control practices planned during site construction activities, and the dimensions, material specifications, and installation details for all erosion and sediment control practices will also be provided on the Erosion Control Plan.

Concerns for stormwater runoff laden with nitrogen can be mitigated by the use of buffer zones and where severe drainage flow volumes are present, construction of freshwater wetlands.

The golf course greens typically require the most management and intensive inputs. Together with the ITHM and G&SWMP, the applicant's environmental design feature includes placement of impermeable liners below the USGA constructed greens. Each drainage layer beneath the greens will be isolated from the native subsoil by placement of an impermeable (HDPE) synthetic liner, which serves as a barrier and prevent conveyance of recharged water from the green areas. An example of the system as shown in Appendix 12, captures water percolating through the green's soil profile and drainage layer, and directs flow through a closed collection system. The liner and greens drainage design will be consistent with other golf course green designs utilized within Southampton (i.e. Sebonack Golf Club). The liner systems have proven to be an effective measure to avoid potential adverse groundwater impacts. Groundwater monitoring and reporting will be used as a metric for the ITHM practices and the liners will provide additional assurance of groundwater quality protection.

Figure 4. Buffer Zone Concept for Golf Courses

Source: NYS BMP Website, Cornell Cooperative Extension, Feb. 2014

Stormwater control wetland construction is contemplated. The approach will include a fore-bay, basically an earthen pool that collects the first flush of runoff, allows the sediments conveyed from the flow to settle (by gravity); and the runoff water to discharge to the constructed wetland at a controlled rate (determined by the elevation of the outflow pipe or channel). These wetland(s) will be constructed accurately and planted with vegetation selected for soil and water conditions. Wetland plants exhibit zonation; meaning where they inhabit the landscape is largely based on their duration of exposure to water (permanently flooded; temporarily flooded; seasonally flooded; etc.). Wetland plants take up their nutrients from the water and can take up large quantities of nitrogen laden runoff waters because of their vascular systems. Wetlands provide a valuable habitat and add to golf course aesthetics. The Hill's civil engineers and freshwater wetland design consultants will provide criteria for a successful constructed stormwater wetland(s) during the design phase of the project[8]

Soil Mixing and Erosion Control

During the construction of the golf course, disturbed areas around greens, tees and bunkers are stabilized with sod, silt fence and hay bales. The soils on the golf course are specific

[8] NYSDEC, Division of Water. (April 1993). Reducing the Impacts of Stormwater Runoff from New Development, Soil and Water Conservation Society, Syracuse, NY.

to the areas of play and engineered for proper drainage, pore space, saturated hydraulic conductivity and fertility. Greens will be constructed as per USGA recommendations for soil characteristics that involve soil particle size and distribution (Appendix 3). Soil erosion within the footprint of the golf course is strictly controlled to avoid mixing soils and disrupting the design characteristics of the soil types. Soil characteristics will be controlled by implementing a quality control/quality assurance (QA/QC) program that will require soil sample collecting and analyses by an independent qualified soil laboratory.

Fairways are typically constructed with native soils, providing the soils possess suitable qualities and can be amended as needed. Ideal soil properties that resemble loam are best and can be blended at the site. Clay layers that may be discovered during earthwork do not provide good properties for golf course construction. If necessary, the clay can be excavated and placed in the proposed stormwater detention pond as an added impervious liner below the synthetic liner. Soil samples will be collected and analyzed by qualified soil labs to report physical and chemical properties. Amendments if needed will be determined after lab reports have been reviewed.

Habitat Restoration/Invasive Specie Control

Disturbed areas of the site, may give rise to opportunistic and invasive plant populations that can influence the site's native ecological balance. To avoid or minimize the potential for this impact, disturbed areas will be restored by the applicant with native plants; and planted areas will be monitored for invasive plants which will be eradicated. Within the golf course, secondary roughs comprised of grasslands will be mowed twice annually (spring and fall) to reduce and control populations of woody plants.

Restoration plant selections will include those which match the localized Pine Barrens ecology and may in some situations be transplanted from within the site limits to sustain local genotypes. A listing of the approved Pine Barrens plant materials is included as Appendix 5.

The Long Island Pine Barren Plan describes typical vegetative habitats being comprised of: "dominant trees: scarlet oak (*Quercus coccinea*), white oak (*Q. alba*), black oak (*Q. velutina*) or red oak (*Q. rubra*). The relative proportions of pines and oaks are quite variable. The shrub layer consists of scattered clumps of scrub oak (*Q. ilicifolia*) and a nearly continuous cover of low heath shrubs such as huckleberry (*Gaylussacia baccata*) and blueberries (*Vaccinium pallidum, V. angustifolium*). Herbs such as: Bracken fern (*Pteridium aquilinum*), wintergreen (*Gaultheria procumbens*) and Pennsylvania sedge (*Carex pensylvanica*) are sparse. Scrub oak coverages tend to be highest in the pine-dominated stands and lowest in oak-dominated stands. (Reiners 1967). Heath shrub abundance decreases with increasing cover by scrub oaks and tree oaks. Forests dominated by oaks have been considered to be a separate forest type (oak-pine forest) by McCormick and Jones (1973), Olsvig et al. (1979), Whittaker (1979), and Windisch (1992)."

Cultivation Practices

The selected turfgrass will require scheduled cultural practices to promote healthy turf and improved soil conditions. The program includes topdressing with soil (sand/soil/peat) as prescribed by physical soil tests, aerification to relieve compaction and improve drainage and soil gas exchange; verti-cutting to remove excessive thatch (organic matter); drill and fill (deep soil coring to improve drainage and soil gas exchange); solid and hollow coring to improve soil drainage and gas exchange; mowing height adjustments to minimize stress; rolling of managed turf areas; and over/inter-seeding programs to enhance turf density. Soil moisture levels will be monitored and controlled by soil moisture meters connected to the irrigation controls.

Cultivation programs relieve turfgrass wear; maintains and improves air circulation and proper soil moisture throughout the course. Monitoring thatch levels (organic matter) in greens to ($\leq$) 3/8-inch in creeping bent grass greens typically requires verti-cutting greens each 7-10 days and topdressing with sand. Improved greens speeds can be achieved with daily rolling, which university research has determined to reduce dollar spot, a persistent disease of Long Island turfgrass.

Dollar spot is also controlled by daily removal of guttation from the plant tissue and reduce the severity of the disease. Methods of removal include whipping/poling (wiping the greens with a flexible pole); dragging a hose or mat across the turfs; and light syringing.

Turf Management Facility

The turf management facility will occupy approximately 20,000 square feet within the golf course facilities. The facility will be equipped with SCDOH Article XII approvable pesticide storage building and fuel tanks (Appendix 8). The maintenance area will include an equipment wash-down pad where wash water will be captured, treated and recycled. The equipment uses a series of settling tanks to remove solids (soil, grass clippings), cyclones to reduce particulate matter, and carbon activated filters to clean the wash water prior to reuse. Debris from the wash water treatment is collected and removed to compost piles or discarded as solid waste. The State's BMP for golf courses cites the importance of turf management facilities as emergency response centers for accidental spills of fuels and chemicals. Typical facilities provide staff break rooms, locker rooms, mechanical repair/parts areas, soil and sand topdressing storage areas, equipment warehousing and act as informational centers for turf employee records, OSHA and MSDS and turf related communications.

Pesticide Applications

The NYSDEC is in the process of developing a pesticide strategy for Long Island (Appendix 9). Applications of pesticides are performed only by persons possessing valid NYS Commercial Pesticide Licenses. Licensure requires classroom and field training, passing of the

NYSDEC examination and mandatory/verifiable continuing education. Applicators are required to maintain daily records of pesticide applications and submit the records to NYSDEC each year. The ITHM program uses options other than chemicals (unless as an emergency response) to solve turf health problems. Pesticide applications may be required once alternative (non-pesticide) treatments have become unsuccessful or when emergency uses are necessary. The NYSDEC and the USEPA have developed lists of reduced risk pesticides. In compliance with the NYSBMP, the applicants have available for use the following assessment tools for predicting potential impacts and decisions regarding pesticide use.

Pesticide Environmental Impact Quotient

The applicants will utilize an IPM program that may require treatment methods using pesticides. IPMs depend on a hierarchy of solving pest problems. The IPM establishes thresholds for pest tolerances (insect counts from traps, weed counts, disease impact measured by square foot areas and locations of turf damage). Pest problems can often indicate other agronomic issues that, once corrected can reverse the problems. For example, crabgrass often invades areas where soils are compacted, turf has been removed and where drainage is poor. Improving the soil compaction by solid tine or hollow tine aerification, adding soil amendments with organic matter, seeding with turf grass and providing supplemental irrigation will establish a dense stand of turf which will out compete the crabgrass for space. The cultural practices would minimize or eliminate the need for treating the crabgrass only with herbicides.

The Environmental Impact Quotient (EIQ) was developed to rate the risk of pesticides to human health and non-target organisms. The EIQ value is derived from mathematically weighting all the risk factors into a quotient. The EIQ is multiplied by the rate of application and percent active ingredient (% AI) to calculate the Field Use EIQ Rating (FUEIQ):

FUEIQ = EIQ x Rate (lbs. /acre) x % AI

The FUEIQ provides a measure of the weighted risk or toxicity of a pesticide expressed as a value per acre. Multiplying the FUEIQ by the number of acres treated provides a risk/toxicity rating for the treated area. Summarizing all applications in this manner provides a summation of risks/toxicity for the entire property over a period. Cornell provides an online EIQ calculator to compare FUEIQ results (http://www.nysipm.cornell.edu/EIQCalc/input.php). A FUEIQ under 25 is desirable. Any value over 100 poses high risks to applicators and the environment.

The *Cornell Guide for Commercial Turfgrass Management* lists the range of FUEIQs for the rate range on each pesticide registered for use in New York. The Cornell publication *Reducing Chemical Use on Golf Course Turf: Redefining IPM* describes the methodology to evaluate pesticide environmental toxicity using EIQ. The Hills will operate the golf course on the basis of the ITHM program. Once applications of pesticides are considered, the turf manager will (in accordance with the BMP) calculate the EIQ for the pesticides under review and compare the

FUEIQ results to select the treatment that is suitable for pest control with the lowest FUEIQ; and a goal of less than 25.

Windows Pesticide Screening Tool

A second model uses the Windows Pesticides Screening Tool (WIN-PST), which is an environmental risk screening tool developed by USDA-NRCS for pesticides. This tool uses site-specific information to evaluate the potential of pesticides to move with water and eroded soil/organic matter and affect non-targeted organisms. The risk of pesticide contamination of either surface water or groundwater is mostly affected by the properties of the pesticide, the properties of the soil, and the amount of rainfall after application. Unlike the EIQ and GUS (groundwater ubiquity score), WIN- PST can be tailored to site-specific soil conditions and management practices. The method uses standard soil properties provided by the NRCS data base or can be adjusted to site-specific soil factors that affect the movement of pesticides, such the depth of the root zone and the organic matter content. The environmental risk can also be evaluated based on anticipated weather (rainfall).

USEPA Pesticide Root Zone Model PRZM-3

This model is used by the EPA for determining pesticide fate and exposure and must be adjusted for golf courses in accordance with the EPA guidance memorandum regarding Golf Course Adjustment Factors (GCAF). The Pesticide Root Zone Model PRZM-3, is a model for predicting pesticide and nitrogen fate in the crop root and unsaturated soil zones. It provides a tool for evaluating pesticide exposure, with expanded capabilities to include nitrogen simulation. PRZM-3 simulates the fate and transport of field-applied pesticides in the crop root zone down throughout the vadose zone, taking into account the effects of agricultural management practices. The model provides estimates of probable exposure concentrations by taking into account the variability in the natural system and the uncertainties in system properties and processes. To enable evaluation of nitrogen (particularly nitrate) exposure via groundwater, PRZM-3 includes a septic system module and capabilities for modeling soil nitrogen fate and transport.

Groundwater Ubiquity Score (GUS) Method

Gustafson (1989) evaluated the difference between leachable and non-leachable pesticides by jointly considering their persistence and mobility in soil. Gustafson found pesticides already detected in groundwater samples were noted as "Known Leachers" and were more mobile and/or more persistent pesticides and developed a hyperbolic function:

$GUS = \log_{10} (T^{soil} 1/2) \times 4\text{-}\log_{10}(K_{oc}))$

Pesticides having GUS values greater $\geq$ 2.8 were leachers. Pesticides having a GUS between 2.8 and 1.8 were defined as transitional with an uncertain potential to leach. Pesticides with GUS values less than 1.8 were defined as non-leachers. GUS method will be used to select turf care products with the lowest GUS values. [9]

The following is an excerpt from the NYS BMP, Appendix B: Groundwater quality of Eastern Long Island, NY, golf courses:

"In New York, groundwater quality has been tested on 27 golf courses in Suffolk County by the Suffolk County government. From 1999 to 2010, up to 42 wells were sampled for a total of 366 sampling events. The samples were tested for a wide range of compounds from nutrients like nitrate and ammonia; metals like arsenic, cooper and cadmium; and 54 organic compounds, including pesticides and metabolites. These sample tests resulted in over 20,000 individual results. These test results are provided on the next page and as a download from the NY BMP web site.

Nitrate was found to be a common contaminate of groundwater in some areas, although 57% did not have a detectable level of nitrate. Twenty nine percent had nitrate concentrations of less than 5 mg/L, 10 % had concentration from 5 to 10 mg/l and only 4 % were greater than 10 mg/L, the drinking water standard. The Nitrogen Challenge with Suffolk County golf courses and the Peconic Estuary Program has set a target goal of groundwater of no greater than 2 mg nitrate/L. Sixty eight percent of the samples tested were below this goal level.

The most commonly detected golf course pesticide was metalaxyl. Fourteen percent of the samples tested had detectable levels of metalaxyl, with concentration ranging from 0.1 to 2.74 ppb (ug/L). An old no longer used herbicide dacthal (the acid metabolite) was detected in 9% of the samples, at concentration as high as 272 ppb. Imidacloprid was detected in 6% of the samples in concentrations no greater than 10 ppb. Several other pesticides (PCNB, propiconazole and iprodione) were occasionally detected at very low concentrations (<1 ppb). The results of this testing would suggest that golf courses are having at most a minor impact on the groundwater quality of eastern Long Island."

The groundwater monitoring programs performed at the Bridge and Sebonack, reported analytical groundwater quality results that are consistent with the above referenced quote from the NYSBMP. As an example, quarterly water samples collected from lysimeters and groundwater wells at the Bridge (Jul. 1998 through Mar. 2009)[10] and analyzed for organic and inorganic compounds reported the following ranges for tested compounds:

Fungicides (NYS Guidance value: 50 ppb)

Chlorothalonil	0.10 ppb-0.20 ppb
Ethofumesate	not detected
Fenarimol	not detected
Myclobutanil,	0.10 ppb-0.40 ppb
PCNB	not detected

[9] Primi, P et al. "Leaching potential of Turf Care Pesticides: A Case Study of Long Island Golf Courses," Summer 1994 GWMR.

[10] Environmental & Turf Services, Inc. Memorandum dated June, 19, 2009 "The Brdige-1st 2009 Quarterly Monitoring Results," Town of Southampton Town Clerk Files, Southampton, NY.

Propiconazole	0.10 ppb-0.40 ppb

Herbicides (NYS Guidance value: 0.44 ppb)

Dicamba	not detected
MCPP	not detected

Nutrients

Nitrate	0.1 ppm-3.7 ppm
TKN	0.54 ppm-1.1 ppm
Phosphorous	0.05 ppm-0.23 ppm

Based on the implantation of similar turf management programs and the NYSBMP practices it is expected that the Hills project will be consistent with these water quality historical results.[11] Disease and insect pressure forecasting is available from Cornell University and UMass via their respective websites. The disease and insect forecasts are determined by field station monitoring; environmental conditions, primarily rainfall, humidity, temperature and hours of sunlight to predict when diseases and insect populations are likely to occur on turfgrass. Using the forecast models provides for more accurate timing of applications of controls, both preventative measures and curatives. The disease and insect models most likely to benefit the Hills will be used to predict pressure from annual bluegrass weevil, pythium, anthracnose and dollar spot (all fairly prevalent on Long Island. The Hills will also utilize an onsite weather monitoring station that will monitor wind direction and speed, precipitation, temperature, and humidity. The system will record the daily data and be used to augment the online disease forecasting model and the irrigation control system. Pesticide selection for emergency use on site will be determined by the turf manager and selected from the following lists in Tables 1 and 2.

Table 1. Pesticide Selection List (Low leaching potential)[12]

Cholorthalonil	Vinclozolin	
Propamocarb	Triexapac-Ethyl	
Metaconazole	Boscalid	Paclobutrizol
Sethoxydim	Carefentrazone-Ethyl	Prodiamine
Bensulide	Spinosyn A	Fluazifop-P-Butyl
Etridiazole	Flutolanil	Ethephon
Bacillus subtilis	Fenarimol	Mefanoxam
Mesotrione	Bispyibac-Sodium Civitas	

[11] Note: (water quality laboratory results for Sebonack Golf Club were not available from the Town Clerk at time of this report preparation.)

[12] "Updated Groundwater Monitoring Plan, The Bayberry Project, Southampton", NY. P.W. Grosser Consulting, April 2013.

Polyoxin D	Propoconazole	Myclobutanil
Azoxystrobin	Dimethylamine salt of propionic acid	
Pyraclostrobin	Siduron	Triadimefon
Dimethylamine salt of dicamba		Aluminum tris O-ethyl
Dimethylamine salt of 2.4-Dichlorophenoxyacetic acid		

NYSDEC Reduced Risk Pesticides and Bio-pesticides

The United States Environmental Protection Agency (EPA) determines which pesticide active ingredients qualify as Reduced Risk. A Reduced Risk decision is actually made at the use level, for a pesticide/use combination.

The following are the Reduced Risk active ingredients registered in New York State for turf and ornamentals. The EPA Pesticide Chemical (PC) Code is a unique chemical code number assigned by the EPA to a particular pesticide active ingredient and can be used in product registration searches. Any pesticide product used in New York State must be registered with NYSDEC.

Table 2. Active Ingredients Considered Reduced Risk for Use on Turf

Active ingredient	PC code	Special Long Island Language
Azoxystrobin	128810	
Boscalid	128008	
Bispyribac-sodium	078906	
Carfentrazone-ethyl	128712	
Chlorantraniliprole	090100	Not for Sale, Use or Distribution in Nassau, Suffolk, Kings or Queens Counties
Fludioxonil	071503	Not for Sale, Use or Distribution in Nassau or Suffolk Counties
Mefenoxam	113502	
Mesotrione	122990	
S-Metolachlor	108800	Not for Sale, Use or Distribution in Nassau or Suffolk Counties
Penoxsulam	119031	

Spinosad	110003	
Trifloxystrobin	129112	

The list of USEPA reduced risk pesticides is included in Appendix 7. Oral toxicity of fungicides used on golf courses are compared to oral toxicity of common substances in Table 3.

Table 3. Oral Toxicity of Common Turf Fungicides Compared to Known Substances*

Product	Active ingredient	Typical Target Organism	Oral toxicity (mg/kg of body weight)
Caffeine	*NA*	*NA*	*250*
Subdue Maxx	Metalaxyl-M	Pythium	669
Aspirin	*NA*	*NA*	*780*
Koban	Ethazole	Pythium	1040
Bayleton	Triadimefon	Snow Molds	1470
Banner	Propicpnazole	Dollar Spot	1517
Eagle	Myclobutanil	Grey Leaf Spot	1600
PCNB	Pentachloronitrobenzene	Snow Molds	1700
Banol	Propamocarb	Dollar spot	2000
Signature	Fostyl-Al	Pythium	2000
Rubigan	Fenarimol	Poa annua	2500
Salt	*NA*	*NA*	*3320*
Chipco 26 GT	Iprodione	Dollar spot	3500
Ethyl Alcohol	*NA*	*NA*	*3800*
Fore	Mancozeb	Pythium	4500
Heritage	Azoxystrobin	Pythium	5000
Clearys 3336	Thiophanate-methyl	Pythium	7500
Daconil Ultrex	Chlorothalonil	Dollar spot	10,000
Prostar	Flutolanil	Fairy Ring	10,000
Vorlon	Thiabendazole	Fusarium	10,000

*Vargas, J. Management of Turfgrass Diseases

Irrigation

Irrigation water supply for the golf course will be from an onsite well. An adequate well size is estimated at 12-inch diameter casing and 120 feet in depth. The estimated maximum output for the golf course irrigation is 1800 GPM; which can be achieved with a variable frequency drive (VFD) electric pump and control system. A water storage pond is designed to include an impermeable liner to store irrigation water pumped from the well and also provide capacity for stormwater detention. Stormwater generated runoff will be captured by a collection system and directed to the manmade pond; mixed with the irrigation water and recycled on to the golf course. A floating treatment wetland (FTW) placed in the pond will provide additional nutrient removal. The FTW floats on the water surface and will not be impacted by the changing water elevations. Once per year the wetland plants will be mechanically sheared and composted for use in the clubhouse gardens. Nutrients absorbed into the wetland plant leaf tissue will be released in the compost and provide a source of plant nutrients.

A manifold system on the pump station will allow the operator to pump water directly from the irrigation well to the golf course. During periods of low rainfall and low water elevation in the storage pond, the by-pass manifold will reduce energy required to initially pump groundwater into the pond and then pump water from the pond to the course. During periods of low precipitation, the pond will receive water from the well to maintain its minimum design water elevation.

The irrigation system will be designed toward water conservation and energy efficiency. Current golf course irrigation systems use moisture meters (both mobile hand held and permanent meters installed throughout the course) to measure soil moisture in shallow and deeper soil levels (2-3-inches to 6-9-inches). The permanent meters send a signal through a wireless router to a computer which activates the irrigation controls. The controls activate only those irrigation heads in the areas that are drying down faster; then end irrigation once an adequate moister level in the soil has been detected by the meter's sensors.

The irrigation system design will include auto-cad style mapping, whereby the superintendent can visually inspect the operations on a computer screen and manually control the irrigation as may be required (based on the hand held moisture meter monitoring). Today's systems simply require the operator to use a cell phone or i-pad to turn on or off the system, adjust an individual or a series of heads or syringe the green(s) in accordance with his direction (for example after applying topdressing).

The golf industry is worldwide and has recognized its obligation to conserve water resources. The golf course irrigation industry leaders (Toro Company and RainBird) have developed sophisticated golf course irrigation systems in response to controlling limited available water. Each company provides additional consultation during design, which will be utilized as the golf course becomes more refined in its development. Manufactures of turf irrigation systems have designed components to manage the irrigation needs which maximize the "water window" (the allowable time to water a golf course due to dry down and player activity; about 6 hours). New irrigation controls permit the golf course to receive water quickly and reduce the overall time for irrigation, while maximizing the pumping capacity of the system. The estimated use of applied water (water actually pumped form the irrigation well) for an 18-hole golf course is between 18-24 MG per year. Using typical standards for evaporation/transpiration (E/T) rates on Long island, it is estimated approximately 50% of the applied water is recharged (with the balance lost through evaporation and plant uptake).

Nutrients

During the past two decades the Town of Southampton has approved three major 18-hole golf courses; Atlantic Golf Club, Bridgehampton; Golf at the Bridge (The Bridge) Bridgehampton and Sebonack Golf Club. The Town planning and approval processes required those project sponsors to prepare environmental impact statements (EIS) that resulted in mitigation methods to minimize and or avoid potential for significant adverse impacts.

During the past several decades the golf turf industry has come under intensifying scrutiny for its role of impacts to natural resources. The increased golf course development projects worldwide which occurred from 1990-2005 generated questions regarding land use, habitat loss, surface and groundwater quality and quantity impacts, economic and social issues, traffic concerns, pesticide fate and other ecological impacts. In some areas of the United States, such as high population areas in Suffolk County, New York that have strong advocacy groups formed for environmental protection, these questions continue to linger and have recently refocused on fertility and turf management programs at existing and proposed golf courses.

For the protection of human health and welfare and protection to natural resources it is critical that turf managers employ practices to avoid or minimize environmental impacts to soils, groundwater, surface waters and wetlands. This section of the analysis includes literature search and review, explores and summarizes the validity of predictable and potential environmental impacts from nitrogen leaching to groundwater, and pollution from runoff generated by golf courses; provides information toward improved understanding and approaches to turfgrass nutritional programs.

There is a need to identify what role a golf course plays in nitrogen loading to groundwater. Researchers from SUNY (SOMAS), Stony Brook, NY, introduced research on nitrogen impacts to the maritime ecology. The research generated in comments to the New York State and Federal mandates regarding the acceptable allowable nitrogen concentrations in drinking water (10 mg/L) and whether the nitrogen MCL is sufficient to protect the marine environment. The university research suggests that N loading to groundwater at or above 10 mg/L (as leachate) is the major source of N inflow to the local Long Island bays. The cause and effect reflected in the research is based on the hydrology of Long Island’s unconfined aquifer, which permits precipitation to first recharge vertically (conveying surface contaminants along with it) downward and after entering groundwater, flow in a down gradient-horizontal direction to the bays. In general terms, Long Island’s freshwater surface waters, freshwater groundwater and maritime bay waters behave as single water resource and basically share an “inter-connected hydrology.”

In January 2014, the Office of the Suffolk County Executive, released the *Executive Summary Update, January 2014 Suffolk County Comprehensive Water Resources Management Plan.* The plan states, "Nitrogen is public water enemy #1, as nitrate contaminant from unsewered and fertilizer use pose a threat to both drinking water supplies and coastal marine habitat and resources."

The 1992 *Long Island Comprehensive Special Groundwater Protection Area Plan* (Koppelman, Kunz, Tanenbaum & Davies) included a section to address golf course as a land use within the groundwater protection areas as *Appendix G: Golf Course Management and Nitrates in Groundwate*r, as originally authored by Petrovic. In the assessment, compared with other land uses evaluated in New York State, "the portion of golf courses having the highest potential for nitrate leaching represents an insignificant threat to the environment as a whole." (Appendix 10).

The analysis of impact potential of nitrogen leaching and runoff affirms previous university research projects that have addressed nitrogen leaching and runoff generated by fertilizer applications on turfgrass. Many of these historical research projects were conducted with input from the USGA. During the late 1990s golf course superintendents from Long Island's Suffolk County volunteered their resources to the USEPA, SCDOHS, NYSDEC and local environmental groups to develop a nutritional program applicable to Long Island golf courses located within the Peconic Estuary watershed. The program, called the "East End Nitrogen Reduction Program for Golf Courses" has specifically targeted a reduction of nitrogen limited to 2.0 mg/L, is still active and administered by Cornell Cooperative Extension.

In February 2014, the <u>New York State Best Management Practices for Golf Course</u> was released by Cornell, Ithaca, NY (Appendix 1). The proposed Hills project has incorporated the BMP into the golf course design and turf management program. With authorization from the authors of the NYSBMP, the criteria is utilized throughout this assessment with the expectation that the course would be designed, constructed and operated within the framework of the BMP.

One objective of this impact assessment is to provide a clearer understanding of how significant golf course generated nitrogen loads and current turf management contribute to large scale environmental degradation of ground and surface waters. A second objective is to provide improved management strategies for nutritional requirements and control of disease and pest populations in order to minimize adverse environmental impacts. A third objective is to clarify methods used to evaluate environmental impacts and/or adverse conditions generated by golf course turf management. The goal is to offer an objective understanding of best management practices recognized as modern management guidelines, used by golf course turf managers and provide information about these practices.

The assessment also identifies the nutritional requirements of golf course turf, water management, fertilizer selection and timing of applications, plant tissue sample and analyses, clipping measurements, soil samples and soil chemistries. Key areas currently under study by the turf industry are: how to clarify the definition of "Healthy Turf," and how one measures optimal turf.

Unlike crop sciences, that use crop yield (for example: the number of bushels of a corn generated per acre) to measure results of nutritional needs or other plant management practices; turf science has no clear or universal "yard stick" to use as a single standard. Typically researchers use turf color, density, plant physiological assessment; or perhaps root mass, or green speed, or player satisfaction, perhaps disease and stress tolerance or simply whether the turf is dead or alive and any combination of these qualitative and quantitative means. The turf industry is working to determine what turf quality and health metrics it will universally accept and apply and how these are specifically measured. It is perhaps difficult to demonstrate to the general public, golfers, environmental groups, and legislators what professional turf managers and turfgrass researchers utilize to measure "successful turf" and what is needed in the form of inputs to meet that goal.

Currently turf managers and turf scientists are defining quality turf as "Healthy Turf." The following definition was developed by the "Plant Health Academy" a cooperative effort among the Environmental Institute for Golf, university researchers (UNC, Clemson, Virginia Tech,) Bayer Crop Sciences, and a highly qualified group of nationally selected superintendents;

Healthy Turf is: "Optimal plant performance where environmental conditions are balanced with management inputs."

Hence if the plant or turf is performing at its optimal level within dynamic environmental conditions, it is in balance; and if it is not, then managing inputs to influence and counter-balance the environmental conditions is necessary to retain optimal plant performance.

Groundwater Description

Long Island, New York is located along the east coast of the United States. The Island extends approximately 120 miles from New York City to Montauk Point and is generally bounded by the Atlantic Ocean and estuaries along its south coastline and the Long Island Sound and various bays along its north coastline. Long Island has several nationally protected estuaries including the Jamaica Bay Estuary, South Shore Estuary, Long Island Sound and Peconic Estuary. The Island's geology formed 21,000 years ago during the ice age as the result of glacier movements that created the Harbor Hill Moraine along the north shore and the Ronkonkoma Moraine which borders along the south shore. The Island has four (4) counties, (Kings, Queens, Nassau and Suffolk) and is completely surrounded by salt water. The area's population of is completely dependent on groundwater for freshwater needs. The source of the freshwater is a groundwater aquifer that is a wedge shape of unconsolidated sands, gravels, silts and clay overlain by glacial deposits of equal geological characteristics. There are three primary aquifers that make up the Island's hydrogeology, the Upper Glacial aquifer at the top of the wedge; the Magothy aquifer in the middle; and the Lloyd aquifer located below the Magothy and above the underlying bedrock. The Magothy is the primary source of drinking water for Long Island, with the Upper Glacial aquifer having been compromised by industrial and agricultural pollutants and the Lloyd aquifer generally unused for water supply due to its vertical depth and regulations to protect withdrawal.

There are two confining units: the Pleistocene Gardiners Clay which restricts flow between the Upper Glacial and the Magothy; and the Raritan confining unit which restricts flow between the Lloyd and Magothy aquifers. Precipitation enters the groundwater system via the highly porous sandy soils and gravels at Long Island's surface. Groundwater has two hydraulic gradients that cause water to flow in both the vertical and horizontal directions. This characteristic is important for understanding how recharge can convey surface pollutants from the Upper Glacial aquifer vertically into the deeper Magothy aquifer (drinking water source). The horizontal movement of groundwater is driven by the higher elevation of groundwater (creating greater head) moving generally and dominated by southerly and northerly directions toward the Atlantic Ocean and Long Island Sound. The horizontal flow is driven by groundwater mounding; where one can think of a "hill of water" flowing outwardly from the center of the peak in all directions towards the base. The recharged water is split into different directions as it flows away from the peak; where the groundwater flows in opposite horizontal directions is known as the groundwater divide. The vertical flow is relatively fast near the surface of the aquifer, approximately 300 feet per year. Age of the water is calculated by its travel time through the Magothy aquifer; with water nearer the surface estimated to be about 10 years old, near the center 100 years old and at the base of the Magothy aquifer the water is about 500 years old (USGS). This indicates that much of the drinking water on Long Island is drawn from a source with high water quality because this "older water" was from precipitation that fell on the Island long before it was developed.

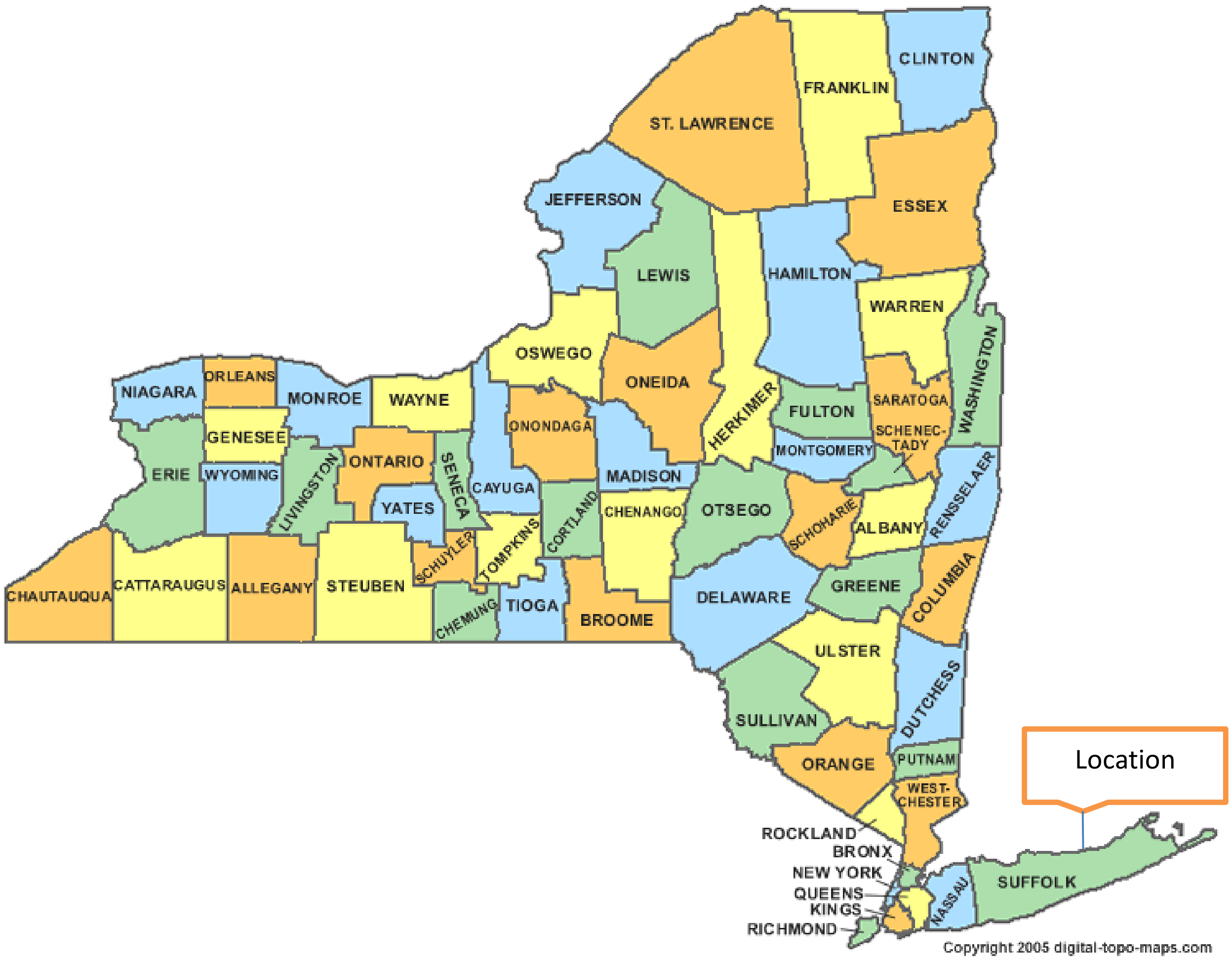


Figure 1. ***Location Map: The Counties of New York State***

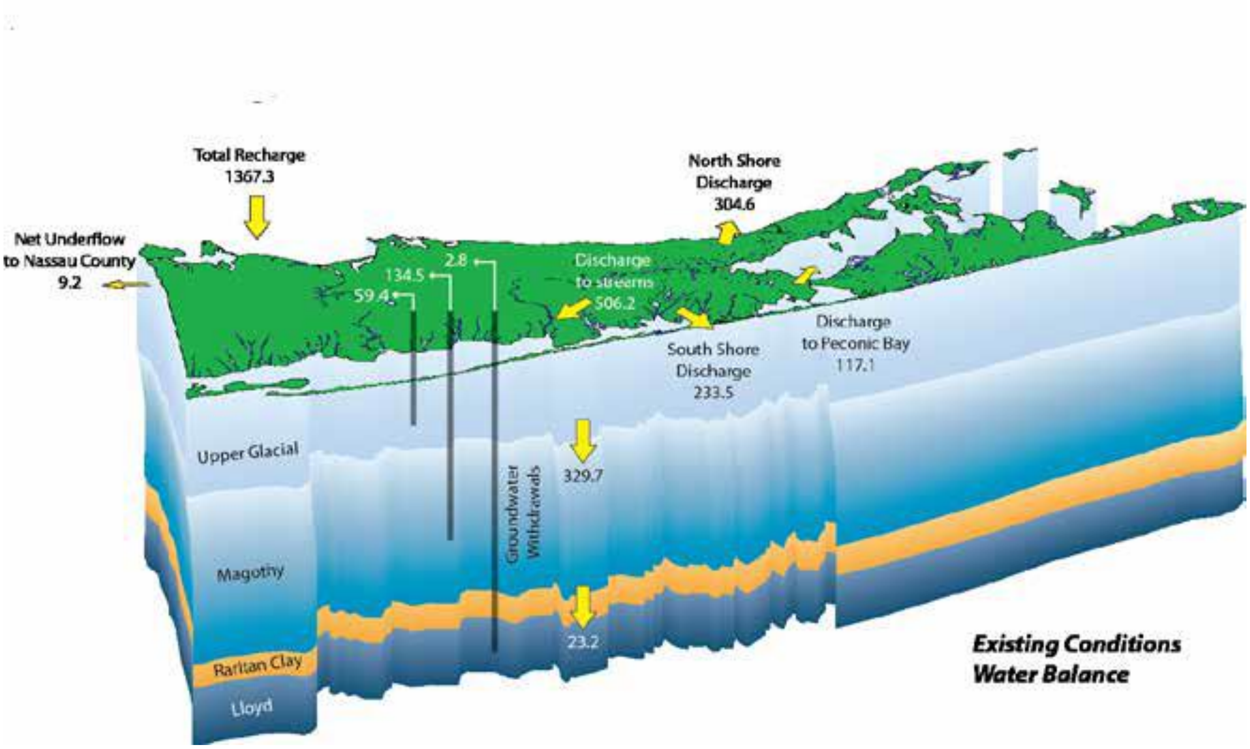


Figure 2.

Suffolk County's Aquifer System & Water Balance

(Source: Executive Summary Update, January 2014 Suffolk County Comprehensive Water Resources Management Plan)

Long Island receives an average of 44-inches of precipitation per year and approximately 50% of this returned to the atmosphere as evapotranspiration (USDA). The water balance from Long Island's averaged precipitation is equivalent to 1600 MGD, ("Proceedings of the Conference on Water Quality on Long Island" Jan. 26, 1993) with the following accounting summary:

780 MGD lost via evapotranspiration

820 MGD enters hydrologic cycle: 480 MGD enters the groundwater and 340 MGD is stream runoff.

The 480 MGD volume is eventually returned to the ocean.

The aquifer system can be thought of as a bubble of freshwater floating on or surrounded by saltwater. The freshwater has a lower density than the salt water so it is "floating" on the saltwater that surrounds the Island. The groundwater quality is generally pure with total dissolved solids at 50 ppm and pH ranging from 4.4 to 6.1.

Within the site, the depth to groundwater varies from several feet below ground surface to approximately 100 feet at the higher elevations of the property. The groundwater general horizontal flow direction is southerly and southeasterly.

General Nitrogen Source Contaminant Factors

One major contaminant source is sanitary wastewater generated by the more than 7.68 million people that reside on Long Island. The western counties of Kings (Brooklyn), Queens and Nassau have municipal sewerage facilities that collect and treat residential and commercial wastewater. Suffolk County has about 1.5 million residents (US Census Bureau 2012 data) many of whom use septic systems (cesspools) which rely on a septic tank for solids collection with wastewater discharged to leaching pools designed to filter (with sand and biological activity) the wastewater as it recharges through the soils to the groundwater. Sanitary discharges are considered a prime source for nitrogen concentrations in groundwater from the 350,000 cesspools within Suffolk County.

Suffolk County is also New York State's largest generator of agricultural revenues producing more than $ 242.9 million (NYS Comptroller). The county has approximately 34,000 acres in farmland and is the top producing county in New York for sales in nursery, greenhouse, floriculture and sod products; the third largest state producer of grapes, peaches and strawberries and the largest producer for tomatoes, cauliflower and pumpkins. There is concern that agricultural land use practices are contributing to Long Island's groundwater pollution including elevated concentration of nitrogen from fertilizers. The County reported that 32,432.19 tons of fertilizer sold in Suffolk with 20.1 percent sold for agricultural use and 79.9 percent sold as residential. The County did not specifically identify exactly how golf course fertilizer sales were categorized. Site specific concerns include the surface runoff from farmland along Lewis Road, which collects along the roadway and is discharged to the two Town of Southampton recharge basins. This runoff has potential to convey agricultural generated pollutants to groundwater.

Golf Course and Turfgrass Nitrogen Source Contaminant Factors

A SRI International survey of New York State's golf industry reported 818 golf courses that generated a total economic benefit of $5.3 billion and supported 56,600 employees with incomes of $1.6 billion. Suffolk County reports 73 golf courses; 35 private clubs and 38 public/municipal courses (Portmess & Petrovic 2011). Suffolk County is home to some of America's finest and oldest golf courses and has hosted premium golf tournaments including men's and women's national championships. Long Island's dominance of well-draining sandy soils provides desirable conditions for golf course construction and provides a pathway for leachable contaminants to enter groundwater via precipitation recharge.

The native sands and gravels are used for sand-soil-peat blends to build greens, tees and fairways that meet USGA recommendations. Many of Long Island's greens use native gravels for drainage layer construction with no intermediate layer needed. However the local sandy and gravely soils (Carver, Plymouth and Riverhead Series) are often rated as having low fertility and high permeability (USDA Soil Survey, Suffolk County, 1975) producing conditions for the potential to leach contaminants to groundwater.

Table 4. The Essential Turfgrass Nutrients.[13]

Nutrient	Symbol	Available form(s)*	Sufficiency range**
*Bold type indicates the form more commonly available to turfgrasses. **Sufficiency ranges are expressed as percentages or parts per million (ppm) on a dry weight basis. Values were obtained from publications by J. B. Jones, 1980, *Turf Analysis,* Golf Course Management, 48:1, 29–32; H. Marschner, 1995, *Mineral Nutrition of Higher Plants,* Academic Press, New York; and E. Epstein, 1972, *Mineral Nutrition of Plants: Principles and Perspectives,* John Wiley, New York. Ranges in some cases are based on general observations and are not necessarily applicable to all turfgrasses or every growing condition or management situation.			
Macronutrients			
Carbon	C	CO_2	44%
Hydrogen	H	H_20	6%
Oxygen	O	O_2, H_20	44%
Nitrogen	N	$\mathbf{N0_3^-}$, NH_4^+	2.75-4.2%
Phosphorus	P	$H_2\mathbf{P0_4^-}$, HPO_4^{2-}	0.3-0.55%
Potassium	K	K^+	1.0-2.5%
Calcium	Ca	Ca^{2+}	0.5-1.25%
Magnesium	Mg	Mg^{2+}	0.2-0.6%
Sulfur	S	SO_4^{2-}	0.2-0.45%
Micronutrients			
Iron	Fe	$\mathbf{Fe^{2+}}$, Fe^{3+}	30-100 ppm
Manganese	Mn	Mn^{2+}	20-150 ppm
Zinc	Zn	Zn^{2+}, $ZnOH^+$	20-55 ppm
Boron	B	$B(OH)_3$	10-60 ppm
Copper	Cu	Cu^+, $\mathbf{Cu^{2+}}$	5-20 ppm
Molybdenum	Mo	MoO_4 +	0.15-0.5 ppm
Chlorine	Cl	Cl^-	not known

13 This publication is available from the Publications Distribution Center, The Pennsylvania State University, 112 Agricultural Administration Building, University Park, PA 16802. For information telephone 814- 865-6713.

Turfgrass and ornamental plants require nitrogen for physiological functions that produce proteins as enzymes, nucleic acids, amino acids, and chlorophyll. Table 4 provides general recommendations for total nutrient levels of turfgrasses.

For turf and ornamental plant cultivation, nutrients and soil amendments are commonly added to soil media to supplement nutrient and soil requirements needed for enhanced plant health. Managing soil pH is important for maximizing efficient uptake of organic and applied nitrogen. Root zone pH can be managed by understanding chemical forms of nitrogen to avoid toxic build-up of ammonium and control pH at the root zone (Mattson, Leatherwood & Peters). Turf roots take up available nitrogen commonly found as nitrate, ammonium and urea from the surrounding soil media; and the form of nitrogen applied will directly impact root zone pH level.

The ionic charges assigned to these nitrogen compounds are: NH_4^+Ammonium (positive ionic charge); NO_3^- Nitrate (negative ionic charge); and $(NH_{2)}2CO)$ Urea (neutral ionic charge). Depending on which form of N the plant root takes up, the plant's root releases an oppositely charged molecule to maintain a pH balance between the root and the root zone soil media. As forms of positively charged cations of N in the form of ammonium are absorbed, the root releases positively charged hydrogen ions (H^+) which reduces the soil's pH. As N is taken up in the form of nitrate, which is negatively charged, hydroxyl molecules (OH^-) are released from the root tip to the root zone soil and pH increases. Different forms of N added to the soil can be converted by natural processes and produce another form of N. For example urea can be converted to ammonium and ammonium converted to nitrate by soil bacteria. Urea is converted to ammonium very quickly (<48 hours) and after two days the ammonium taken up by the root tip will result in releasing hydrogen molecules and decreasing root zone soil pH.

Mattson, Leatherwood and Peters demonstrated the effect of nitrogen form on growing medium pH by growing rose plants hydroponically in nutrient solutions containing different percentages of ammonium. After five days, the treatments of 8 percent and 16 percent ammonium solutions taken up by the roots initially dropped the pH one to two units, as bacteria converted the ammonium to nitrate. As nitrate became available in these treatments the pH increased over time as only nitrate was available. In the treatment using 31 percent ammonium solution, after the two to three unit drop in pH, the pH remained fairly constant for five days both forms of N as nitrate and ammonium were available. Forms of N as urea and ammonium are commonly grouped together as "ammoniacal nitrogen." Although soil pH can be adjusted with addition of limestone the experiment illustrates how the form of applied N impacts soil pH.

Nitrification occurs once ammonium is added to warm, moist soils and the bacteria in the soil convert ammonium to nitrate. In sandy soils, the most important nitrogen change in the environment is the nitrification process (Wolkowski, Kelling & Bundy).

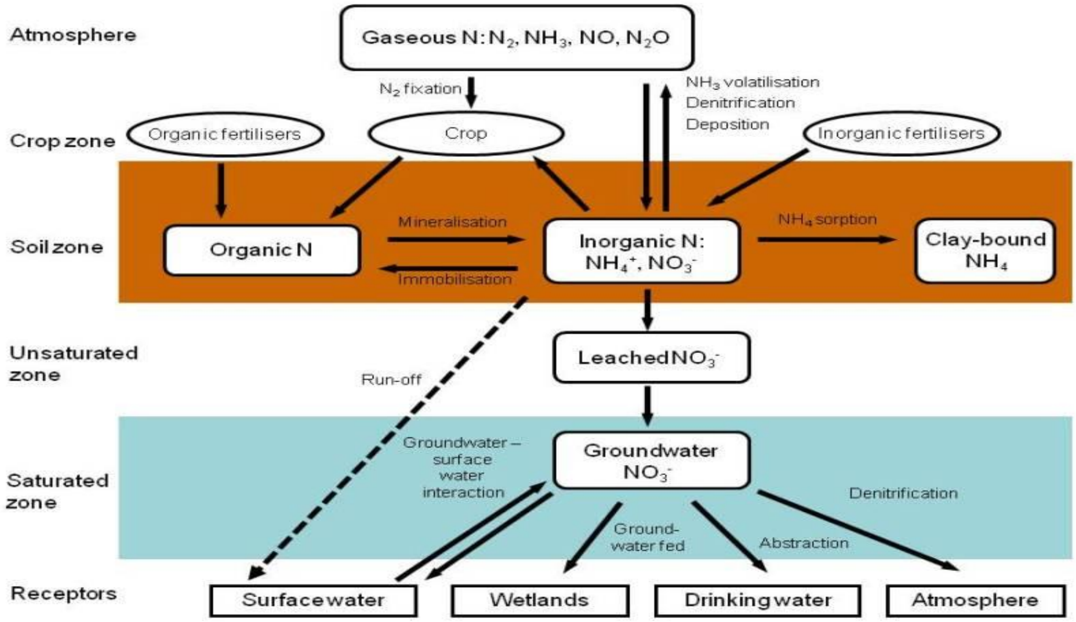


Figure 3

The Nitrogen Cycle

(Source: google search)

Nitrate (NO_3^-) leaches more readily in sandy soil than finer-textured soils because sandy soils have a lower water holding capacity and typically sandy soil characteristics are chemically inert (there are fewer chemical bonds formed between sandy soil particles and nitrogen ions as compared with soils that contain silts and clays). Nitrate can leach rapidly through channels formed in sandy soils by insects, burrowing animals, and deep roots. Organic matter in sandy soils is usually lower than fine-textured soil. The organic matter is a source of nitrogen. Golf course management controls thatch (organic matter) levels on greens, tees and fairways. These management processes include core aeration, deep verti-cutting and straight sand top dressing programs.

Golf course turf management has come under a high level of environmental scrutiny and is often categorized in the same context as agriculture and sod farm management. However there are significant differences in how crops are managed and how a playing surface for golf is managed, even within the same geographic region. Dr. Bruce Clark, a noted turf pathologist at Rutgers, the State University of New Jersey, reminds us that turf management science is still a relatively new and evolving science; with many historical evaluations based on agricultural crop sciences. Although there may be very broad similarities of nutrient programs among crop and turf land uses there needs to be more refined discussion on golf course turf management and environmental impacts aimed to separate and distinguish playing turfs from crops, including sod.

Modern golf course turf management and its potential impact to local environmental degradation can best be understood by education. To help educate municipal land planners, the USGA published, "Reviewing Golf Course Proposals, Materials for Local Officials," prepared by Cook College, Rutgers. The publication offers information and additional resources for municipalities to use for golf course environmental impact assessments, practical options for site use, land use regulations, community impacts, preservation areas, mapping of ecological conditions, construction issues, water resources, IPM, maintenance facilities, and post construction monitoring. Today, the golf industry's direction is toward "sustainability."

At the GCSAA 2014 Industry Conference, Orlando Florida, sustainability was defined having three interrelated components; people, planet, and profits. Each of these components depends on the other two for sustainability to be successfully realized.

The significance of N loading to ground and surface waters from golf course managed turfgrasses may be misunderstood by the general public, regulatory/municipal administrators and even researchers that have been exposed to poorly prepared studies. Kenna and Snow provide an excellent summary of this problem. Golf courses became the subjects of environmental concerns during the late 1970's and early 1980's when droughts occurred in California. During those decades, golf courses became highly regulated with respect to water use. As new course construction boomed in the late 1980's through the 1990's course development projects came under attack due to potential impacts on natural habitats, pesticide use, and nitrogen loading. Unsubstantiated claims were made by anti-development groups about harmful impacts generated from golf courses simply to fight off real estate development projects.

By 1989, the USGA implemented an environmental impact assessment program to evaluate golf course development and management by conducting university studies focused on fertilizer and pesticide impacts on ground and surface water. Nitrogen leaching was investigated by seven universities primarily by using bucket lysimeters to evaluate the potential for downward movement by water of nitrogen through the turfgrass-soil system. The studies reported that very little nitrogen leaching occurred when nitrogen was properly applied, soil types were considered, and water management for supplemental irrigation and rainfall were properly planned for (Kenna & Snow). Sandy soils were more prone to leaching than loam soils; during year one of establishing turf and resulted in nitrogen leaching potential ranging from 11 percent of applied N for pure sand root zone mixes to one percent or less for root zones containing greater percentages of silt and clay. Simply by utilizing a USGA recommended root zone mix for greens construction, the N leaching potential was reduced to about three percent compared to a pure sand green construction where leaching potential was approximately 7.6 percent of an annual application rate of 12 pounds of N per 1000 sf. Pure sand greens resulted in N loading that exceeded the Federal MCL of 10 ppm; in no cases did the USGA recommended green construction with sand- peat root zone mix did the concentration of N leachate exceed 10 ppm. As newly established turf matured through years two and three, less nitrogen leached and light applications of slow release nitrogen sources applied frequently provided excellent control to avoid leaching potential.

Branham who conducted the research for the USGA reported that over a two and one half year period, in undisturbed loam-soil, N leaching was less than one percent through a depth of four feet. The nitrogen was recovered in grass clippings (38 percent to 35 percent), thatch 17 percent to 13 percent) and soil (25 percent to 13 percent); and Branham suggested the remaining was lost through de-nitrification and volatilization (40 percent to 18 percent).

The USGA examined the impact of nitrogen loading by experiments conducted in Pennsylvania on fairway plots. The plots were described as having slopes of 9 percent to 13 percent, good quality loam soil, and turfs comprised of either creeping bentgrass or perennial ryegrass maintained at ½-inch height, with annual applications rates of N of 4 lbs. per 1000 sf. Other studies were performed to evaluate N loading and runoff impacts in Georgia, and the effects of buffer strips in Oklahoma. The results of the studies showed that dense turf cover reduces the potential for runoff losses of nitrogen, with greater runoff losses expected on highly compacted soils; and on soils with very high moisture content. Buffer strips reduced nitrogen runoff when soil moisture was low or moderate, but were not effective when soil moisture was high. Nitrogen runoff potential was reduced significantly when a slow release product (sulfur coated urea) was used compared to a more water soluble product (urea). Several factors determine the leaching potential of a fertilizer applied to turf (Petrovic, A.). These include: the rate of application, the source of the N and how soluble or readily available it is, the season the application is made, irrigation/rainfall events and the soil types. Turfgrass management can control the rate of application, timing of application and selection of the source of nitrogen. Thus according to Petrovic, nitrate leaching potential can be maintained near zero, or at an acceptable level with proper turfgrass management.

The risk of runoff laden nitrogen and conveyance to surface waters was found to be much greater than nitrogen leaching to groundwater. The study conducted at Oklahoma State University designed a management program to reduce pesticide and nutrient runoff from Bermudagrass turf maintained under fairway conditions (Baird, J. Basta, R., et al.). The study compared buffer treatments of various sizes to evaluate effectiveness in reducing runoff under simulated rainfall events. All buffer treatments reduced chemical runoff compared to treatments applied to areas with no buffer. Vegetated buffer strips can be used to effectively control both runoff containing sediments and nitrogen; and can be as simple as grassed swales adjacent to fairways and greens that capture and slow the velocity of “first flush” rainfall generated runoff (Corbitt).

Environmental damage can occur when excessive losses of turf nutrients (nitrogen and phosphorous) are released into surface waters. Aquatic problems include increased algal growth, hypoxia and eutrophication. Algal blooms can be triggered by total nitrogen and phosphorous concentrations in the range of 1.0 ppm and 25 ppb (Baird). New York State and Suffolk County regulations have removed phosphorous in standard fertilizer mix applications unless the application is performed to establish new turf on bare soils and/ or soil sample analyses performed by a qualified laboratory determine phosphorous is needed. All fertilizer applications are banned between October 31 and April 1 (regardless of other factors such as soil temperatures, turf tissue analyses or soil chemical analyses) (Suffolk County Legislators, 2010).

Human health is also effected by high concentrations of nitrogen; the primary pathway for the toxin's entry being ingestion. Toxicology, the study of poisons, teaches us, "all things are toxic, depending on the dose" (Casarett & Doul). The amount of nitrogen consumed is relevant to the mass weight of the subject; and infants are at particular risk because of their low body mass. Feeding liquid diets to infants (usually less than 3-4 months old) with formulas mixed from water containing high concentrations of N subject the infant to risks of a condition whereby the oxygen carrying capacity in the blood is reduced by the presence of nitrates; known as methemoglobinemia ("blue baby" syndrome). To protect human health from consuming nitrogen contaminated water, the USEPA limits the MCL of N to 10 mg/L in drinking water. The lowest recorded concentration of nitrogen in water that posed reported health problems was 20 mg/L (Petrovic).

The CDC records show the first infant fatality reported in the U.S. was caused by well water contaminated with nitrogen in 1945. Over the next 25 years, 2000 cases of methmogloinemia were reported worldwide with a 10 percent mortality rate. Sporadic cases were reported during the 1980s, 1990s and 2000s. Petrovic reports virtually no cases in the U.S. in recent years; with a 1982 occurrence involving a well containing a concentration of 121 mg/L of nitrate and a six week old infant; who recovered once the child's formula mix no longer used the well's contaminated water.

East End Nitrogen Reduction Program for Golf Courses

During the late 1990s, in direct response to concern for Long Island's water quality, the USGA, USEPA, SCDOH and local golf course superintendent developed the "East End Nitrogen Reduction Program for Golf Courses" which is administered by Cornell Cooperative Extension. The program includes reduction of potential nitrogen loading to groundwater from golf courses nutrient programs to a maximum of 2.0 mg/L.

The voluntary reduction in nitrogen load (2.0 mg/L) at golf courses within the Peconic Estuary watershed represents less than half the nitrogen loading from residential development (USEPA). Local golf courses continue to come under environmental scrutiny and superintendents respond by participating to voluntarily reduce turf chemical inputs. The local golf industry was recognized for their past efforts for participating in the Nitrogen Reduction Challenge as summarized by the following USEPA news release:

> **"**NEW YORK **--** More than 88 percent of the golf courses on the east end of Long Island have accepted a challenge from the U.S. Environmental Protection Agency (EPA) and its government and private partners to protect the health of the Peconic Estuary and other local waters by reducing their use of fertilizers. This is the first time that a group of golf courses in one geographic area of the country have voluntarily agreed to better manage

their fertilizer use to limit the amount of nitrogen that enters ground water, ultimately winding up in rivers, streams and the estuary. Thirty of the thirty-four East End public and private golf courses are participating in the program.

'This is the first time that a large segment of the golf industry in one area has voluntarily come together to reduce fertilizer use and the nitrogen it produces to protect the future of our estuaries,' said EPA Regional Administrator Jane M. Kenny. "The protection and restoration of coastal waters requires everyone to do his or her part, and the golf courses of eastern Long Island are certainly setting a laudable example.' Through the Challenge, the USGA and Cornell provide technical assistance to participating public and private golf courses, enabling each course to better manage its fertilizer use.[14]"

One of the primary concerns for turf managers is the response from golfers and course owners when nutrient programs and turf management practices are voluntarily changed in response to outside environmental pressures or controlled by legislative mandates. Another concern turf managers have is what the long term outcome is with respect to overall turf quality, diseases, and stress.

Typical university field studies are excellent indicators; however actual applications on the golf course can yield varying degrees of success and failures. One long range study performed on the golf course was conducted by Dr. Frank Rossi, Cornell University. Rossi conducted a long term field evaluation of turf management practices, turf quality and environmental impact by using reduced chemical applications at Bethpage State Park. The reduced chemical management of the putting surfaces was conducted over a five year period and included a golfer survey to evaluate satisfaction with ball speed roll and visual quality. Although the project involved various treatments to evaluate the effects of low input levels on turf and sustainability, the golfer survey indicated the putting surfaces provided acceptable visual quality and ball roll. This suggested that for the golfer, visual and playability may have a wide range of acceptance. Furthermore, healthier turf is expected when mowing heights are raised, fertilizer applications increased and mowing frequencies decreased from seven days per week to five (Rossi, F. & Grant, J.).

Snyder and Cisar evaluated nitrogen leaching by monitoring the vadose zone on warm season grasses grown on USGA constructed greens. Although the study did not expressly address cool season grasses, it remains relevant to understanding nitrogen leaching potential. The researchers found appreciable levels of nitrogen leached (20 ppm to 200 ppm) from greens constructed on sand soils during the early stage of grow-in, but decreased with increased turf density. Fairways evaluated in the study which cover larger areas of a course compared to greens, were found to leach less nitrogen and showed no increase of nitrate in groundwater during the seven month study. In part the study identified turf density was essential to reductions in nitrogen leaching potential.

14 USEPA website news announcement.

Cation exchange capacity (CEC) is influenced by the soil texture, type of clay present, and percentage of organic matter and to some extent the soil pH. With predominately high sand content in constructed greens there is increased potential for low CEC, a concern for turf managers. Increasing CEC (with topdressing containing peat; leaving clippings and managing thatch) will increase soil moisture holding potential and can reduce nitrogen leaching potential (Frank & Horgan). Dr. Kevin Frank (Michigan State University) and Dr. Horgan (University of Minnesota)[15] reported mature turf should be fertilized at reduced rates to minimize leaching potential. During a ten year on-going study at MSU after approximately four years after grow-in, high rates of N applications (5 pounds N per 1000 SF) produced high nitrate-nitrogen leachate levels at concentration of 20 ppm to 40 ppm; while low rates of nitrogen applications (2 pounds of N per 1000 SF) resulted in leachates with concentration at or below 5 ppm. Fertilization programs need to be adjusted based on specific golf course turf and environmental conditions, season of application, regulatory requirements, water needs, disease pressure and general plant health.

One important aspect of nitrogen leachate prediction is accounting for dissolved organic nitrogen (DON); which is a source of total nitrogen loading that is often misunderstood as a significant source in older turf stands. A planned fertilization program that minimizes potential for excessive nitrogen applications is discussed in the following section.

Turf Management to Avoid or Minimize Potential N-Loading

In a 2011 summary report, Petrovic offered turf management practices to minimize or avoid potential water quality damage from nitrate leaching and run off. The recommendations follow monitoring programs at golf courses in Suffolk County and literature reviews that summarized and debunked previous assumptions regarding turf fertilization and nitrogen fate. Petrovic has clarified the golf course turf and nitrogen-water quality issue. He found that on average about 25 percent to 35 percent of fertilizer nitrogen applied is expected to be lost to the atmosphere by de-nitrification and volatilization, especially when urea is used. Fertilizer nitrogen stored in thatch and soils was approximately 36 percent to 47 percent of the amounts applied. The high sand content of areas on the golf course is generally limited to greens which are normally 2 to 4 acres of turf within the 60 to 100 acres of turf on an 18-hole golf course. Comparatively, with nearly 1000 golf courses in New York State, there would be nearly 2000 acres of greens, out of a total of 30 million acres in the state; or 0.00007 percent of the land area.

Cropland in New York accounted for 20 percent and residential lawns 2.3 percent of land area. Petrovic illustrated that suggesting golf courses hold the highest potential for nitrate leaching to groundwater was grossly misunderstood and that research showed the threat to the environment as a whole was insignificant. When research did show nitrate leaching potential from turfgrass, the use of best management practices could be employed as mitigation measures. Leaching potential increased in circumstances where excessive nitrogen rates were used; more frequently when highly water soluble formulations of urea, ammonium nitrate, ammonium sulfate, and potassium nitrate are used; when fertilizer applications were made during turfgrass

[15] "Cool-Season Turfgrass Nutrition, Fertilizers and Programing" 2014 GCSAA Conference, Orlando, FL.

dormant periods; and where excessive irrigation increased potential for leaching nitrate through the soil. Petrovic explains the worst case scenario is substantial amounts of water passing through the soil when formulations of soluble nitrogen are in the soil.

Turf managers consider additional approaches to refine their specific turf nutritional needs that yield high turf quality with minimal environmental risk. Solely relying on turf color, or "traditional" fertilization dates offer less reliable diagnostic and science based assessments of nutritional needs. When asked what the most common mistake turf managers make in fertilization programs, Horgan and Frank replied immediately with, "Overwatering."

The dynamics of nitrogen uptake by turfgrass is driven by water and mass flow; nitrogen laden water is absorbed by the root hairs and trans-located by the vascular system. Nitrogen applied by foliar methods is absorbed by the plant at the stomata with residual amounts that enter the soil available for root absorption. After fertilizer applications excessive irrigation rates and natural rainfall events significantly increase risks of nitrogen leaching and runoff potential. Soil type, temperature and root density are important to factors governing nitrogen leaching rates (Frank & Horgan). Selection of fertilizer physical characteristics, release mechanisms, and carrier types should be considered to minimize leaching and runoff potential. Physical aspects include prill size and blends, carrier types are quick release, slow release or a combination of each and release mechanisms include: microbial, osmosis, hydrolysis and physical breakdown.

Turf managers are challenged with providing optimum turf conditions at the lowest cost. Decision for selecting a quick release versus a slow release fertilizer is sometimes cost driven with different leaching and runoff potential outcomes, and benefits as summarized in Table 5.

Table 5. Comparison of Nitrogen Carriers (Frank & Horgan)

Factor	Quick Release	Slow Release
Cost	Less Expensive/Lb. N	More Costly/lb. N
Initial Plant Response	Rapid	Slow
Burn/Salt Index	High to Moderate	Slow
Duration of Response	Short to Moderate	Moderate to Long
Leaching Potential	High to Low	Low
Efficiency	Generally good	Good over time

Table 6. Tissue Sufficiency Range for Nitrogen in Cool Season Grasses (Frank & Horgan)

Species	Tissue Sufficiency Range (Nitrogen expressed as percent)	Typical Annual N Needs (Lbs. N/1000 SF)
Creeping Bentgrass	4.50 - 6.00	2.5-3.5
Perennial Ryegrass	3.34-5.10	3.0-5.0
Kentucky Bluegrass	4.0-4.5 (est.)	2.0-5.0
Fine Fescue	1.5-2.5 (est.)	1.5-3.0
Annual Bluegrass	4.0-4.5 (est.)	3.5-4.5
Typical Greens/Tees	4.0-5.0 (est.)	2.0-6.0
Typical Fairways	4.0-4.5 (est.)	2.0-4.5
Typical Roughs	0.0-2.0 (est.)	0.0-2.5

Estimated tissue sufficiency – no data reported

Table 6 shows typical nitrogen sufficiency ranges for cool season turfs. These guidelines are important to recognize when planning fertilization programs but cannot be considered independent of the following factors:

<u>Optimum Temperature Ranges</u>

- For shoot development: (60-75 F: air temperatures)
- For root development: (50-60 F: 4-inch-soil temperatures)

<u>Seasonal Growth Activity</u>

- Dormant stage: No application is necessary
- Early spring: Generates good color, competitive advantage over weeds, and good density (but may produce rapid growth and deplete carbohydrate reserves needed for summer stress).
- Late spring: Generates intermediate responses, improves stress prevention before summer.
- Summer: Provide light applications of nitrogen (0.5 lbs. N/1000 SF) for color; providing disease pressure is low (for example gray leaf spot pressure and its impact on rye grass).
- Fall and late fall: DiPaola and Beard describe late fall as, “around the last fall mowing.” When growth has essentially stopped and there is no clipping production. Roots are active and photosynthesis continues; producing carbohydrates but little growth. Risks with late fall fertilizer programs include promoting snow molds and wrong selection of fertilizer carrier types (N carriers that are dependent on soil microbes for nitrogen release would be a poor choice for late fall programs and potentially increase pollution potential).

Turf managers recognize that nitrogen release mechanisms influence the applicability of fertilizer choices as it pertains to the release mechanisms and environmental factors:

- Microbial action mechanisms are driven by soil microbes, which are themselves affected by soil temperatures, moisture levels and oxygen levels and would be a poor choice for late fall applications in the northeast.

- Osmosis release mechanisms are driven by nutrient (ion) concentration levels and naturally move from a higher area of concentration to a lower area.

- Hydrolysis releasing mechanisms allow water to break down compounds and release nitrogen into the soil, obviously influenced by water, particularly unpredicted rain storm events.

- Turf mangers also consider the salt index when selecting fertilizers that use hydrolysis as the basic release mechanism. Most quick release nitrogen carriers are water soluble and can cause nitrate to leach to the soil. Salt release can cause plant injury (burn) and discoloration and over time require flushing past the root zone and upper soil profile.

- Physical breakdown mechanisms depend upon breakage of the coatings to release nitrogen. Physical breakdowns occur when the particles are mowed, walked on, dragged with a brush mat and releases are often rapid. Table 7 provides a listing of nitrogen release mechanisms of common fertilizers and the respective salt index associated with water soluble mechanisms of release.

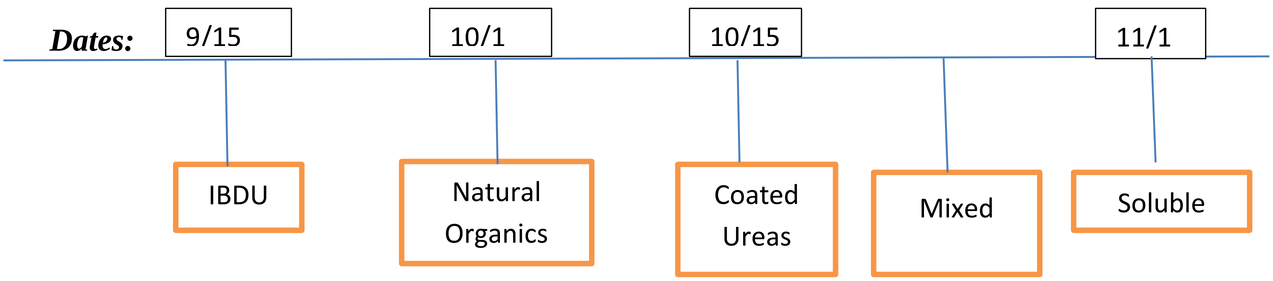
Table 7. Fertilizer Types and Nitrogen Mechanism Considerations

Quick Release N Carriers (salt types)	***Release Mechanism***	**Salt Index**
Ammonium nitrate	water soluble	105
Ammonium sulfate	water soluble	69
Potassium nitrate	water soluble	74
Monoammonium phosphate (MAP)	water soluble	30
Diammonium phospahte (DAP)	water soluble	34
Calcium nitrate	water soluble	53
Urea	water soluble	75
Quick/Slow Release Carriers (Methylene Urea)	Microbial/water soluble if blended	75
Slow Release N Carriers		
Synthetic organic N carriers- methylene urea based	Microbial/water soluble	24
Natural Organic (animal waste, sewage sludge)	Microbial	2
Isobutyraldehyde (IBDU)	Low solubility/hydrolysis	5
Polymer and Sulfur Coated Urea	Temperature driven due to low solubility ; low microbial action	

According to Frank and Horgan the following recommendations are considered for late fall applications:

- Soluble N sources should be applied about the time turf growth ceases.
- Sulfur coated ureas should be applied 10 to14 days before turf growth ceases.
- Natural Organics should be applied 3 to 4 weeks before turf growth ceases.
- IBDU: Should be applied 4 to 6 weeks before turf growth ceases.
- Mixed Soluble and slow release: Should be applied 4 to 10 days prior to turf growth ceasing depending on the percent of slow release and type of carrier.

Frank & Horgan: Typical Cool Season Turf Late Fall Timing Strategies



Turf managers use spoon-feeding methods on sandy soils with low nutrient retention capabilities. Spoon feeding applies low rates N at frequent intervals. (Carrow, et tal). Vargas emphasizes how proper turf nutritional programs are essential to fungicide efficacy. It is common knowledge that turfgrasses already stressed due to poor nutritional programs take longer or fail to recover from foliar diseases such as dollar spot, rust and leaf spot. Increased potential for snow mold can be exacerbated by excess nitrogen applications in the late fall. According to Vargas there is an abundance of data that supports nitrogen ability to reduce disease. A summary of nitrogen and disease impacts from Vargas is shown in Table 8.

Table 8. Effects of Nitrogen Application on Turfgrass Disease

Severity of Diseases Increases	***Severity of Disease Decreases***
Pythium blight	Dollar spot
Brown Patch	Rust
Gray leaf spot	Red thread
Stripe smut	Pink patch
Microdochium patch	Anthracnose
Typhula blight	Necrotic ring spot
	Summer patch
	Melting-out
	Leaf spot
	Take-all patch

The correct balance of available N is necessary to maintain optimum turf physiological performance, fungicide efficacy, and when properly applied will maintain the turf's physiological equilibrium. This balance provides turf with only the nitrogen needed for health requirements, offering less residual nitrogen forms that negatively impact the environment through leaching and runoff. Measuring turf nutritional needs only by subjective visual analyses (color, density, and growth) is often inconsistent and varies due to time of day, moisture levels and each observer's interpretation. Vargas recommends (as a rule of thumb) 0.5 lbs. N /1000SF per growing month in order to receive the maximum benefit of fungicide applications.

Establishing the overall nutrient balance is essential to optimal plant health. The Bridge has monitored groundwater for the past nine years to determine the course's nutrient and pesticide concentration impact to local groundwater. The long term average goal for nitrate in groundwater is limited to 2.0 mg/L. To achieve these goals the total nitrogen fertilizer application rate is limited to 3000 pounds per year or the equivalent of 0.9 lbs. N/1000 SF. To date, there have been no reported significant impacts to the groundwater quality or negative impacts to the golf course.

The impact of nitrogen on turf disease control and the efficacy of an applied fungicide will only be realized when the turf manager has properly identified the pathogen. For the Hills' project, the turf manager will use a qualified turf pathology laboratory to correctly diagnose the turf disease, select fungicides based on the NYSBMP model and NYS reduced risk pesticide list (as first methods of treatment as applicable to the specific pathogen) and determine if nitrogen will help or worsen the condition. The turf manager will determine what environmental condition(s) exist that increased disease risk and implement cultural practices to reduce the persistence of pathogen incidence. Improvements to soil health will be evaluated to determine if the disease risk can be minimized by soil amendment and microbial activities.

Table 9 represents typical microbial levels recommended for two mixes of turfs, bluegrass/rye and bentgrass/fescues. The microbial levels are part of the soil food web; and inoculation of soils with microbes and soil amendments with compost are higher priorities than applications of synthetic inputs. The Hills' ITHM program requires soil sample analyses for these organism populations on a seasonal basis.

The applicants will analyze the soil for microbial levels prior to the final design of the project, to determine the necessary levels with respect to the selected turf species. Microbial levels will continue to be monitored throughout the operational stages of the golf course as part of the ITHM program.

Table 9. Suggested Microbial Levels for Turf Grass Mixes

Spring	**Bluegrass/Ryegrass**	**Bentgrass/Fescue**
Active bacteria	15 to 25	15 to 25
Total bacteria	100 to 300	100 to 300
Active fungi	10 to 20	15 to 25
Total fungi	50 to175	100 to 300
Flagellates	10000 +	10000 +
Amoebae	10000 +	10000 +
Ciliates	50 to 100	50 to 100
Nematodes	20 to 30 no root feeders	20 to 30 no root feeders
% Mycorrhizal Colonization	40 to 80	40 to 80
Summer		
Active bacteria	10 to 25	10 to 25
Total bacteria	150 to 300	150 to 300
Active fungi	5 to 20	10 to 25
Total fungi	100 to 200	150 to 300
Flagellates	10000 +	10000 +
Amoebae	10000 +	10000 +
Ciliates	50 to 100	50 to 100
Nematodes	20 to 30 no root feeders	20 to 30 no root feeders
% Mycorrhizal Colonization	40 to 80	40 to 80
Fall		
Active bacteria	1 to 5	1 to 5
Total bacteria	75 to 100	175 to 300
Active fungi	1 to 5	1 to 5
Total fungi	50 to 75	175 to 300
Flagellates	5000 +	5000 +
Amoebae	5000 +	5000 +
Ciliates	50 to 100	50 to 100
Nematodes	10 to 20 no root feeders	10 to 20 no root feeders
% Mycorrhizal Colonization	40 to 80	40 to 80

Note: units are ug/gram of soil
Source: Appendix G DEIS Bayberry Project (Sebonack Golf Club)

- **Turf Tissue Sampling**

Turf tissue sample testing is growing in popularity to asses turf nutrient balance. Table 6 provides recommended levels of nitrogen tissue levels for various cool season turf. There are two methods that can be used to monitor nutrient level and relate the condition to the response from fertilizer; diagnose nutrient deficiencies (micro and macro nutrients) to (1) determine underlying turf problems and (2) to provide verification of visual observations (Murphy). The preferred tissue test method is the total analysis of the elemental content of plant tissue and sap. The method is quantitative and precise. The second method is a rapid test of the soluble nutrients in the plant sap.

For the Hill's ITHMP, tissue samples will be collected monthly during the growing season from areas of good and poor turf; and avoid collection of weeds, debris and other foreign matter. The laboratories will be contacted in advance of sample collection and shipment to clarify all sample preservation requirements and diagnostic processes. There are final decisions about the use of turf tissue analyses. These include frequency of sample collection (weekly, seasonal); composite sample collection or discreet sample collection; and accuracy with respect to the dynamic conditions of turf's physiological activity and environmental influences (traffic wear, mower damage).

Unlike crops where critical nutrient level standards can be set based on yield; turf does not equate to a "yield based standard" and critical nutrient levels are instead based on density, color, and other turf qualitative parameters as well as its growth (Murphy). Murphy found there is a "significant limitation to the use of tissue analysis for nitrogen status monitoring because the "interpretation of results suffers from limited quantitative nitrogen response data" (as compared to maximum yield goals for crops). Optimum yield is used for turf rather than maximum yields as is used for crops. Murphy suggested and evaluated the relationship of dollar spot disease severity on *Penncross* creeping bentgrass in a randomized complete block design experiment with five replications; analyzing nitrogen content in clipping samples (to evaluate various treatments of N application) to define a parameter for optimum levels of tissue nitrogen content. Murphy also found that the clipping yield (as a measurement of creeping bentgrass growth) increased in a linear fashion with increasing tissue content of N. A content in clippings of 4.5 percent N will provide bentgrass recovery from dollar spot; and suppression of dollar spot will require clipping nitrogen content of approximately 5 percent but will increase growth rates and could reduce carbohydrate reserves and limit root development (Murphy). These percentages of optimum nitrogen levels are impacted by periods within the growing season and should be considered in terms dynamic; not static conditions. Murphy brings attention to the obvious need for the turf industry to establish a "universal standard" to define optimal turf conditions, which may not be possible with respect to the dynamic state.

The applicability of tissue sample analyses to determine nutrient decision making was examined by Gelernter and Stowell. They suggest that misleading nutrient deficiencies may be reported in tissue test results; but the lack of nutrients may be caused by secondary soil related issues including: soil compaction, waterlogging, black layer, high salt levels, and anaerobic conditions. Their research discovered that nutrients were in the soil, and simply unavailable for root uptake because of limitations caused by the soil physical properties. The researchers found tissue samples collected during different periods of growth during the day or collected in areas of shade or no shade will show different tissue analytical results for nutrient levels. Using a regression coefficient calculation of the results, a comparison of 197 golf course green soil and tissue analyses was used to correlate 20 different nutrient parameters; with no statistically measureable correlation found except for a weak correlation between copper and nitrogen values. The researchers discouraged using tissue sample analyses alone to decide turf nutrient level requirements. The Hill's will utilize multiple diagnostic tools (soil and tissue chemistry, microbial levels, soil moisture holding capacity, etc.) for turf management decision making.

- **Soil Sampling**

Cultural practices are critical to turf nutrient balance to optimize turf health. Shearman and Rieke acknowledge there is no soil test for predicting nitrogen nutritional needs for turf. There are several reasons for this problem. Soil analytical results can show adequate nitrogen concentration in the soils, yet the nitrogen is unavailable for turf root uptake. Causes include lack of oxygen in the soil which blocks aerobic bacteria activity; poor drainage and saturated soils (causing low O_2 levels), and temporal quantities of N that exceed plant uptake needs (due to soil temperatures, seasonal growth, compaction, sunlight/shade exposure timeframes, and salt). Nitrogen and calcium supplemental sources that include sulfur as a base chemical can under anaerobic conditions, lead to formation of black layers in the soil profile. Many of these conditions can be corrected through cultural means including: soil aerification, improved sunlight exposure, soil amendments, and proper irrigation. Soil analyses will include physical characteristics to evaluate soil properties and evaluate what conditions exist or can be altered to provide the most efficient environment for root zone nutrient uptake. The Hills' turf manager will be cognizant of which fertilizer release mechanisms (Table 4) are involved, what form the nitrogen is in, if the salt index is a concern, and what background soil conditions influence availability of nutrients and the efficiency of root uptake.

- **Clipping Weight**

Clipping weight measurement is a useful tool to evaluate shoot growth and can be used to fine tune nutrient programs. Depending on the turf species desired in the stand and time of season, monitoring growth through clipping weight can aid in understanding when to aid the cultivar population in gaining a competitive advantage over less desirable turfgrass. Turf managers desiring higher populations of bentgrass over *Poa annua* must not only correctly time nutrient supplemental applications to promote bentgrass and "starve" *Poa* but also use clipping weights to aid in monitoring of progress of plant population shifts. Clippings management is also critical because clippings are a source of nitrogen, with 35 to 38 percent of the applied nitrogen found in clipping tissue. Clipping weights are a more effective nitrogen management tool when used in conjunction with turf tissue analysis.

Turf managers who typically return clippings to fairways and roughs must account for the nitrogen loads from this source. Two recommendations of the "East End Nitrogen Reduction Program for Golf Courses" are turf equipment wash-down pads with wastewater collection and treatment facilities; and removal of grass clippings placed on bare soils as bulk storage (i.e. compost piles) to minimize sources for nitrogen loadings due to runoff and recharge.

- **Dissolved Organic Nitrogen (DON)**

Pare, et al preformed an experiment with ^{15}N isotope to trace applied nitrogen to various turfgrasses and collected water that passed through lysimeters to evaluate leaching potential. The researchers' conclusions are quoted below in their entirety, because of the significance of their findings regarding the measurement of dissolved organic nitrogen and its contribution to the total nitrogen mass balance equation of accountability:

> "In this lysimeter experiment, the amounts of NO_3 lost through leaching were inversely related to plant N uptake. The application of $_{15}N$-labeled fertilizer demonstrated that one-third to one-half of the NO_3^- leached was derived from N accumulated in soil **before** the $_{15}N$ application, presumably from re-mineralized organic N. Therefore, the mineralization of soil organic N should be accounted for when determining the fertilizer requirements for golf greens to reduce the risk of N leaching. Dissolved organic N was a significant component of the total N leached from golf-green profiles, and was assumed to be derived primarily from background soil and rhizospheric N. Measuring DON in leachates allowed for a nearly complete recovery of the applied fertilizer $_{15}N$ in most planted lysimeters. We conclude that part of the N losses traditionally attributed to gaseous N emissions (volatilization and denitrification) in golf greens would be due to the leaching of dissolved organic N."

The aforementioned quote emphasizes a common error with theoretical calculations used by some reviewing agencies during golf course impact with respect to nitrogen leaching potential. DON must be considered when predictive methods are used to evaluate potential leaching from additional nitrogen applications and it is particularly important when older turf stands are involved (Frank & Horgan). The actual fate of nitrogen is influenced by a number of factors, including soil pH, moisture, organic matter, temperature, aeration, N carrier, clippings, and soil texture and structure. The Pare research was conducted in a greenhouse in Canada, and one must cautiously apply these conclusions to Long Island outdoor locations.

Field experiments conducted at the University of Illinois showed that 52 percent of the N applied as fertilizer found its way into the thatch and soil organic matter, 30 percent was removed in the clippings, 8 percent volatilized, 6 percent was in the plants, and *none leached*. The only way to accurately determine the fate of nitrogen on a turf in Long Island is to measure it (Turgeon 2014).

- **Soil Moisture**

Irrigation and rainfall cannot be overlooked when evaluating nitrogen leaching and runoff potential. Water is not only the resource that becomes contaminated by excessive nitrogen but also the driving media that moves nitrogen compounds from the soil to water. Course topography and soil characteristics play important roles, but water is the primary attribute in nitrogen concentration levels, leaching and runoff potential. Moisture meters measure the moisture level in upper 4-inches of the soil and have become widely accepted by the industry. The meters can be either hand held or permanently installed. The installed meters are commonly integrated with the irrigation system's central controller; and allow irrigation only in areas directed by the moisture meter settings. This innovation will have a profound impact on controlling nitrogen loading by runoff and groundwater recharge. As Frank and Horgan have expressed, the greatest and most common mistake turf mangers make with their cool season turf nutrient program is "overwatering."

Excessive irrigation can increase runoff potential and easily drive nitrate molecules from sandy soils to groundwater. One of the more sensitive conditions that increase potential nitrogen loading to ground and surface water is the golf course grow-in period. The grow-in is also a time where irrigation and proper soil moisture levels are critical. Grow-in starter fertilizers commonly include phosphorous, which is a primary environmental concern. Turf managers sometimes exclude or minimize the amount of phosphorus during the grow-in period to reduce the competitiveness of annual bluegrass (*Poa annua*) against creeping bent grass (*Agrostis stolonifera*); however on low organic sandy soils, (i.e. USGA greens) the developing turf seedlings require nitrogen and phosphorus once the roots develop. As water is needed for germination, the balance among seedling nutritional needs, consistent soil moisture levels, and available supplemental nutrients applied at rates that minimize environmental impact can be controlled by the turf manager.

The Hills will install moisture meters connected to the irrigation central control system to provide the turf manager a most important tool during the grow-in. Moisture meters reduce risks of overwatering; can increase the success of seed germination; can be adjusted for providing advantageous conditions for selected turf species; minimize release of nitrogen and phosphorous to the environment. Early establishment of turf and increased density during the grow-in period significantly reduce environmental impact potential of nutrient loading to ground and surface water.

The use of a fertigation system during grow-in greatly aid the manger in establishing turf. The fertigation system optimizes nutrient inputs which are injected into the irrigation water during applications. This method provides the correct amounts of specific nutrients during applications to the landscape. Fertigation systems can provide a method for applying inputs designed for improving healthy soils, and plant physiological defense systems. The Hill's turf managers and planners have considered the course topography to evaluate grow-in methods such as the use of hydro-seeding and sodding. Before the final design stage, the Hill's will carefully plan how best to quickly develop high density turf and healthy root development.

Figure 5. ***Integrated Turf Health Management Triangle*** *(OSU Extension, Management of Turf Diseases, L-187, Mar. 2011)*

- **Cultivar Selection**

Cultivar selection is of superior importance. Trewarth's climatic classification for Long Island, NY is Dcfb; temperate continental, with no dry season, and cool summers; allowing good conditions for cool season grasses of the Pooidea subfamily of grasses. More common turfgrasses used in the Long Island region include fescues, bluegrasses, ryegrasses, and bentgrasses. The Hill's turf managers have a relatively broad range of turf varieties from which to select. Selection of cultivars will be completed later in the design phases of the project, and as stated will consider soil and growing conditions specific to the Hill's site location. Table 10 shows a representative comparison of turf species and general annual amounts of nitrogen required.

Table 10. Nitrogen Requirements for Cool Season Grasses (Frank & Horgan)

Species	Typical Annual N Needs (Lbs. N/1000 SF)
Creeping Bentgrass	2.5-3.5
Perennial Ryegrass	3.0-5.0
Kentucky Bluegrass	2.0-5.0
Fine Fescue	1.5-3.0
Annual Bluegrass	4.0-6.0

Estimated tissue sufficiency – no data reported

Table 11. Establishment Vigor of Popular Cool-Season Turfs (Turgeon)

FAST RATE OF ESTABLISHMENT & VIGOR

Perennial rye grass
Tall fescue
Fine fescue
Creeping bentgrass
Colonial bentgrass
Kentucky bluegrass
Rough bluegrass

SLOW RATE OF ESTABLISHMENT & VIGOR

Table 11 represents the rate and vigor of turfgrass establishment and illustrates how turf selection during the grow-in period can impact nitrogen applications and for potential leaching and runoff. Runoff will be directed to "naturalized" areas and constructed stormwater wetlands where the sediments and nutrients conveyed by rainfall can be absorbed by the otherwise unfertilized, minimally managed areas.

Integrated Turf Health Management Program & Protocols

The ITHMPs are based Integrated Turf Health Triangle (Figure 5) developed Ohio State University. OSU recommends the following management practices to improve success of ITHMP:

Diagnosing Turfgrass Problems

Proper diagnosis is a critical step in the management of plant diseases. Without a solid diagnosis, it is impossible to suggest or develop an adequate management strategy. The more the superintendent knows, the better equipped the turf manager will be to take corrective action. For turfgrass disease diagnosis, the more one knows about the host, environmental, and biotic factors that favor disease development (the disease triangle), the greater likelihood of making a correct diagnosis. Confirmation of disease diagnostics will be conducted at recognized turf diagnostic laboratories. The following 6-step approach will be used for diagnosing turfgrass problems at the Hills.

1. **Define the problem**

The staff will gather as much information as possible about the situation such as grass species, cultivar or variety, age of the stand, recent fertilizer or pesticide applications made, cultural practices implemented, weather trends, irrigation practices, use of growth regulators, history of problems, etc. It is essential to correctly identify the plant affected and to be familiar with its healthy state and characteristics. Staff will take seasonal effects into account.

2. Examine the entire turfgrass plant community

The applicant's approach will be to observe the entire plant community. For example, if there is a potentially diseased fairway, staff will look at other golf courses in the area to assess what may be happening, and contact other golf course superintendents within close proximity of the Hills to inquire about similar conditions. At the Hills, staff will inspect other fairways to see how widespread the damage is and examine the entire fairway; noting light conditions, wind direction, slope of the land, air movement, soil conditions, etc. Once completed, staff will focus on the affected plant(s) or area. By examination of the leaves, stems, crowns and roots, staff will make observations to avoid quick decisions or a wrong diagnosis.

3. Patterns: Diseases don't occur in straight lines

It is important to look for patterns. Is only a single plant affected? Is the problem restricted to a certain area or a single species? Are the symptoms randomly distributed or are there distinct patterns or clear lines of demarcation between healthy and affected plants? Is the damage occurring in a pattern consistent with recently performed maintenance practices? Random patterns often are indicative of diseases or insect pests whereas uniform damage such as streaks or lines or damage over a large area is indicative of an abiotic (chemical, physical, or mechanical) culprit.

4. Timing of events: How did the problem develop?

Did it appear suddenly or over time? Has the damage spread or stayed in the same location? Does the damage coincide with changes in the weather? Progressive development and spread of a problem over time is commonly associated with a pest or pathogen. Acute damage is typically caused by abiotic factors: environmental stress, mechanical damage (caused by mowers, topdressing, abrasive sand, etc.) or chemical injury.

5. Look for evidence of a pathogen or pest activity

The Hills' superintendent will look for key diagnostic signs or symptoms that are indicative of pathogens or insect pests. For instance, the presence of large numbers of fruiting bodies or mycelium might lead one to suspect a fungal infection. If after gathering sufficient background information, staff finds no evidence of a chemical misapplication and/or staff has eliminated the possibility of pathogens and insect pests, the superintendent will retrace his steps and focus his diagnosis on abiotic factors. This is where diagnosis may require the services of a plant pest or disease diagnostic laboratory to narrow the probable causes. Photographs or digital images to aid the diagnostician will be taken with any samples of turf collected for lab analysis.

6. **Seek professional help**
   The Hills will utilize agronomists from USGA; disease experts from UMass, Amherst, Penn State, and Rutgers.

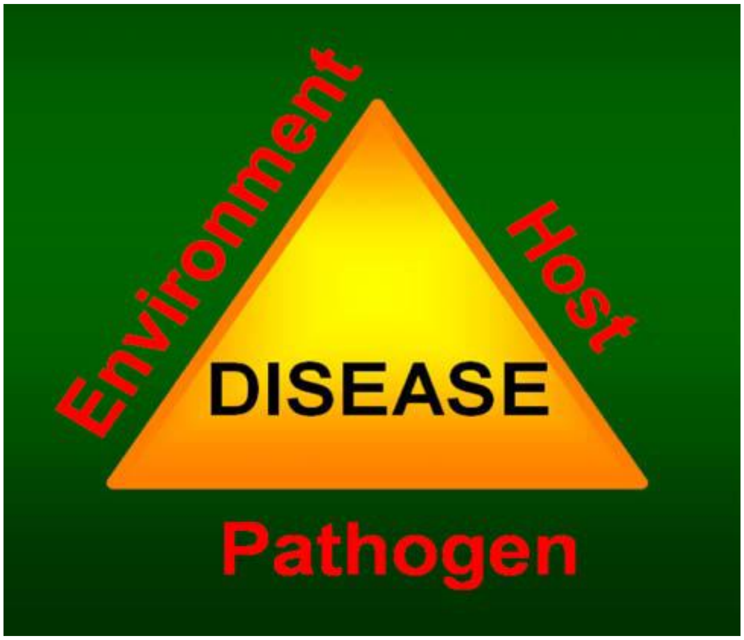


Figure 6. Disease Triangle

Plant pathologists have developed a simple model called "The Disease Triangle" to illustrate this concept. Practices which influence the temperature, moisture and fertility status of the turfgrass have the greatest impact on disease development. (Source, Management of Turfgrass Diseases, Mar. 2011 OSU Extension Bulletin L-187)

As pressures mount to reduce inorganic fertilizer and pesticide inputs on turfgrass, interest has increased regarding the development and use of integrated pest management (IPM) programs that either forego or limit the use of pesticides. Although voluntary in some situations, fungicide use is prohibited or strictly regulated in other situations such as in the case of home lawn or residential turfgrass disease management. The first line of defense to preventing or minimizing disease is through the selection and/or use of disease resistant turfgrass species/cultivars and the use of certified seed.

Information regarding disease resistant turfgrass will be obtained by contacting local seed distributors, extension specialists and via the National Turfgrass Evaluation Program (NTEP; http://www.ntep.org). The use of genetically resistant turfgrass shall be considered when establishing or renovating turfgrass areas or in situations where over-seeding is used, such as the range.

The second line of defense against turfgrass diseases is the use of cultural management practices that favor turfgrass health over pathogen activity. Cultural practices related to seedbed preparation prior to establishment are critical for seedling and root diseases such as Pythium damping-off and the patch diseases. Sand-based root zone mix considerations for putting greens and athletic fields are equally critical. Under certain situations, it may be possible, although difficult, to modify poor quality soil conditions under existing turfgrass swards through the use of core aerification and organic matter topdressing programs. Disease management in established turfgrass swards is often achieved by modifying cultural management practices such as mowing, watering, fertilization, tree pruning, top-dressing and core aeration. As mentioned previously, intensely managed golf course turfgrass is often more predisposed to environmental and biotic stresses and so it is crucial that agronomic practices be timed to optimize health. By providing growing conditions that favor plant growth over pathogen development or activity, it is possible to minimize or avoid disease.

Plant pathologists have developed a simple model called “The Disease Triangle” to illustrate this concept (Figure 6). Practices which influence the temperature, moisture and fertility status of the turfgrass have the greatest impact on disease development.

Fungicide applications are often essential where there is a demand for high quality turfgrass during environmental periods that favor pathogen growth. In general, fungicides are most effective when applied prior to the onset of disease symptoms (referred to as preventive applications). Fungicides applied after the onset of disease symptoms are typically made to slow or stop pathogen activity and to protect asymptomatic or healthy turfgrass. These type of applications are referred to as being curative. Keep in mind the pathogen is not killed with curative applications.

Other considerations for effective use of fungicides include: (a) selection of product; (b) use of proper water volume (i.e., minimum of 2 gallons per 1,000 ft^2); and (c) sprayer nozzle selection (for liquid applications), and spreader calibrations for granular applications.

The NYSDEC requires certified applicators read and follow label recommendations when applying fungicides as with any pesticide.

Several recent advances in the use of biological control strategies to manage turfgrass diseases have been reported, such as the application of material rich in organic matter and the use of antagonistic microorganisms. Relatively few products are commercially available that provide consistent and predictable reductions in disease.

Lastly, high-value turfgrass systems, such as golf course putting greens are intensively managed (i.e., daily mowing, irrigation, core aerification, topdressing applications.). Although frequent manipulation allows for timely intervention of problems, it can also lead to increased wear and the predisposition of turfgrass to environmental and biotic stresses.

The following lists of some of the many complex factors provided by OSU that are considered by golf course superintendents as they strive to manage healthy golf course turfgrass.

The ITHM Complexity Factors Considered When Managing Golf Course Turfs

Human Relations

- Client Relations
- Crew Size and Organization
- Human Error Language/ Ethnicity Dynamics
- Experience Level of Employees
- Expectations & Opinions
- Amount of Play/Use

Budget

- Staff
- Equipment
- Management options
- Revenue Generation

Cost

- Recovery Equipment
- Irrigation system Characteristics
- Mowers
- Sprayers and Spreaders
- Injection Equipment

Environment

- Weather
- Shade
- Thatch
- Air Movement
- Water Dynamics
- Temperature
- Soil or Root zone Mix Characteristics
- pH
- Soil Compaction

Agronomics

- Fertility (dates for fertilizer applications are limited to between April 1 and October 31)
- Mowing heights and frequencies
- Air Movement
- Irrigation
- Thatch
- Core Cultivation
- Heat Stress
- Drainage
- Shade/Sunlight
- Trees & Flowers

Playability

- Aesthetics
- Compaction & Wear
- Topdressing
- Hard Surface Maintenance
- Traffic
- Syringing
- Turfgrass Selection (genotypes)
- Water Quality
- Repair
- Mulching
- Soil Type
- Age of Turf Stand/Facility Turfs

Pathogens & Pests

- Diseases
- Insects
- Grassy and Broadleaf Weeds
- Wildlife Management

Regulatory Concerns

- Product Availability & Selection
- Rates & Means of Delivery
- Environmental Stewardship

For standard IPM/BMP/ITHM practices, the Hills will conduct daily course monitoring and surveys to monitor pest and disease issues.

IPM requires establishing thresholds for when pests need to be tolerated and when damage exceeds this threshold. The above photograph is of grub damage in a "naturalized native grass area" where no abatement measures were needed.

Equipment and Products for ITHM Relevant to Turf Management and Turf Chemical Reduction

In addition to the standard mowing equipment (fairway, greens and rough mowers) the ITHM will require specific turf equipment to maintain the course. The following equipment will be used in conjunction with best management practices:

- Greens aerator with various tines
- Fairway aerator with various diameter and depth tines
- Fairway soil reliever (solid tines and solid knives)
- De-thatching units for fairways and greens
- Powered turf boom sprayer with GIS system, computer and spray nozzle boom curtain
- Irrigation control systems and Fertigation System
- Soil biological, physical and chemical sample collection equipment
- Plant tissue sample collection equipment
- Lysimeters
- Water sample collection kits
- Disease diagnostic kits

Turf products will include materials that contain bio-stimulants:

- Cytokinins
- Auxins
- Sea kelp extracts
- Amino-acids
- Fungicides
- Bio-pack mixtures (microbial stimulates, microbes and soil enhancements)
- Dolomitic Lime
- Plant Growth Regulators
- Certified seed mixes

These materials stimulate plant growth and can be found in products such as: Sea-Cal; Growth Products Bio-packs, Companion and Restore; Primo Maxx.

Ground and Surface Water Monitoring Protocols (G&SWMP)

The Hills will provide the technical expertise and funding to develop Ground and Surface Water Monitoring Protocols (G&SWMP). The G&SWMP will be a voluntary program used to demonstrate how the Hills' inputs and turf management practices influence the local water quality. The monitoring program also serves as a management tool to evaluate the efficacy of the turf management practices.

The Hills and the Town of Southampton will establish reasonable threshold limits for selected compounds and of pesticides and nutrients that are applied. These limits will act as "triggers" and generate a response by the Hills management team (resampling and/or turf management responses) to address exceedances. The program will be used to evaluate the actual post construction impact of applied pesticides and nutrients.

Southampton has requested similar post construction quarterly water quality monitoring at golf courses, specifically at Sebonack Golf Club and Golf at The Bridge. The Hills and the Bridge have approximately the same areas of managed turf. The total allowable fertilized/input managed area of the Bridge is 80.38 acres and the proposed Hills golf course managed turf area is 78 acres; and the Bridge serves as a reasonable model for the expected water quality impacts from the Hills. Historical water quality monitoring results collected at the Sebonack Golf Club provide a reasonable prediction of groundwater impacts associated with golf courses constructed with lined greens. Results from these project sources showed no significant impact on ground or surface water quality has resulted from the ongoing golf course management programs.

The G&SWMP must consider existing conditions and future local ground and surface water quality impact potential generated through up-gradient land use, agricultural runoff, area wide sanitary discharges and stormwater controls positioned along Lewis Road. The background water quality data will require careful evaluation to establish the parameters for the monitoring program and the thresholds for the concentration of compounds (triggers) and potential sources.

The anticipated G&SWMP will involve installation of groundwater monitoring wells (couplets), suction lysimeters, sampling points at Weesuck Creek, and possibly coordination with other involved agencies (SCDOH, NYSDEC).

The G&SWMP will include recordkeeping of the depth to water, groundwater directional flow, dates and quantities of applied inputs, rainfall and temperature information (recorded by the onsite weather station), and irrigation rates.

Summary Comments

Long Island's geology is dominated by glacial till comprised of gravel and sandy soils; and its public drinking water supply is from the sole source aquifer with a federal standard of MCL for nitrogen (N) of 10 ppm designed to protect human health and the environment. Although a MCL of $\leq$ 6.0 ppm may be desirable to protect aquatic resources, unsewered sanitary systems, especially residential systems installed in close proximity to the shoreline are the primary source of N. N leaching and runoff from golf courses has been shown to be minimal based on water quality monitoring, professional turf management practices, existing regulations and implementation of ITHM and BMP protocols. The Hills golf course is expected to yield a maximum nitrogen discharge of $\leq$ 2.0 ppm, well below the 10 ppm standard set for public health protection and below the 6.0 ppm suggested for environmental protection of aquatic eco-systems.

The research papers and literature reviewed for the Hills proposed golf course integrated turf health management plan identified approximately 40 years of university and industry experiments and data assessment to determine the significance of inputs from golf courses and potential impacts to ground and surface waters.

As early as the middle 1980s the USGA and researchers concluded that established turf grass stands, when properly managed by turf professionals posed low potential for environmental damage from inputs. The use of historical and current management tools available to turf managers, minimizes potential for leaching and runoff to the ground and surface waters, even in soils dominated by sand.

The turf management strategies include the following: monitoring turf nutritional requirements through soil and tissue testing as measures to assess nutrient status, monitoring clipping yield to assess turfgrass growth and density, controlling thatch and mat accumulation to maximize soil moisture levels and soil gas exchange, periodic sampling and monitoring water quality at ponds, streams, and other water bodies to determine if runoff is occurring, soil sampling for physical and chemical characteristics, including CEC, implementing moisture metering for improved irrigation controls, and using NVDI instruments to record conditions as impartial and consistent method of measurement.

This management plan explains how professional turf management programs minimize environmental degradation of ground and surface waters. Without reductions in turf quality, university research concludes that golf courses can reduce inputs including nitrogen loads ($\leq$ 2.0 mg/L, well below the Federal and New York State drinking water standard of 10 mg/L).

Best management strategies for nutritional requirements minimize potential adverse environmental impact. These techniques have been outlined above and in the NYSBMP for Golf Courses. Methods of evaluating environmental impacts and adverse conditions must be consistent and objective. There are many sources of nitrogen, with sanitary discharge and disposal methods used on Long Island a major contributor; well in excess of nitrogen generated from turf.

DON must be considered when measuring total nitrogen. Properly planned and constructed, the Hills' golf course will act as a "green space" providing a potential sink for existing nutrient laden urban and agricultural runoff. Visual observations and review of the drainage designs indicate localized stormwater generated from the agricultural lands flows to the low point of Lewis Road and into the Town of Southampton's recharge basins. If this stormwater quality is compromised and recharged to groundwater, it may be significantly impacting the water quality at Weesuck Creek. Land uses up-gradient of the proposed Hill's project must be carefully evaluated to assess what impacts these have on surface and groundwater quality.

There is a growing trend in golf turf management to utilize Precision Turf Management (PTM). PTN uses global positioning satellite mapping (GPS) of golf course micro-environments (3,000-5,000 SF units) for improved and select use of turf management practices (pH adjustment, irrigation, pesticide and nutrient applications). According to the February 2014 issue of Golf Course Industry magazine, the use of this technology is expected to grow. The technology can significantly reduce the use of resources applied as inputs which will be placed only in specific areas of need and these areas continuously monitored. The growing acceptance of this technology already in practice on large scale agricultural properties, may in the long run be a critical factor in reducing the potential for nitrogen leaching and runoff concerns. The Hills in in the process of assessing this technology and its applicability with respect to the anticipated construction and operation of its golf course.

Concerns for “drift” described as the dispersion of applied products beyond the intended area of application can be minimized and avoidable by equipment selection and calibration. Powered turf boom sprayers with air induction spray nozzles include boom curtains. The spray nozzles for turf applications are located 20-inches from the ground surface. The turf boom sprayer is specifically designed for product application in a downward direction (on to the turf). Spray rates (gallons per minute) and ground speeds (amount of the product applied per area, i.e. fluid ounces of the product per 1000 square feet of turf area) is governed by an onboard computerized sprayer pressure and vehicle ground speed regulating system. The computer is preprogramed by the certified applicator with the required spray rate. As the vehicle’s ground speed changes (such as with topography) the rate of spray is changed by adjusting the pressure and therefore the flow. This system provides an automated calibration to occur in real time, so that the correct amount of product is consistently applied to the turf regardless of the boom sprayer’s vehicle speed. Certified applicators are required to inspect spray equipment and calibrate the sprayers before applications. With the turf sprayer control system is a GIS system. The system is designed to specifically operate the equipment and apply inputs only within the predetermined GIS mapped areas. The GIS map is created for the areas only where the inputs are intended (i.e. each green, fairway and tee) and automatically activates only the sprayer nozzle(s) (typically located 14 to 20-inches apart horizontally) programmed for the mapped area. The over spray or under spray during product application is for practical terms eliminated or in the worst case reduced to 14 to 20-inches. For additional control of inputs boom sprayers are equipped with a boom curtain. The curtain covers the boom from the above the spray nozzle to approximately 2 inches above the turf canopy. This attachment reduces impact from changing wind directions, wind speeds and vehicle direction operations on the spray applications, thus directing the spray downward on to the turf.

Turfgrass when compared to other cultivated plants (vegetable crops, nursery stock) creates a “carpet-like” canopy and dense root system. Turf provides more significant area for input collection and uptake than most row-crop plantings. Row-crop plantings allow for a greater area of un-vegetated soil exposure, where applied inputs by-pass the plant leaves and roots and if mobile, move through the soil profile to groundwater or hold potential for dispersion via sediment laden runoff. Acre for acre turfgrass offers more vegetative cover than most all agricultural and nursery products.

The ITHM program together with the G&SWMP will provide an integrated system for turf management. The lined greens and stormwater collection/treatment for the development systems will offer additional environmental protection.

The NTEP uses a system of rating turfgrass performance trials and is based on visual observations, rating each parameter (color, density, etc.) on a scale of 1 to 9 with 9 being the highest qualitative number. The NTEP rating is used by trained professionals that understand its use and their abilities to arrive at consistent and useful turfgrass ratings. There is no need to significantly change or eliminate the NTEP rating system largely because its use is limited to the NTEP. What must be considered is a tool for the broader use that can evaluate turf health; and provide a consistent standard that is acceptable to a wide range of stakeholders.

To accurately perform ITHM, historical turf information (chronic insect populations, persistence of plant disease, cultural practices including dates for aeration and materials used for topdressing etc.) will be developed by the Hills' turf manager and will be evaluated over time. Soil sample (collected from tees greens and fairways) analytical results, plant tissue analysis and cultivar types are all necessary for long term ITHM development.

All major varieties of turf grasses are not the same and within the particular major types available for use at the Hills site (Kentucky bluegrass, fescue, bentgrass, annual bluegrass and rye grass). There are hundreds of genetic variations of these grasses. These genetic variations have a profound effect on how each cultivar reacts to specific turf management practices. What may be good for one type of cultivar (i.e. high rates of fertilization) may not produce the best results for another cultivar of the same turf type. This can provide growth advantages to one type of plant compared to another. However while that type may do well with increased fertilizers (and the other be not as responsive) it may not perform well under high heat stress, or rebound after insect attack. The surrounding ecology and environmental conditions (soils, available sunlight, and topography) will be indicators for selection of turfgrass selections to avoid the "wrong" plant that will require large inputs of water and turf chemical applications to maintain it.

The concentration of soil based nutrients required for healthy turf and turf growth varies depending upon the turf species, specific cultivars, and the specific nutrient. Ideally turf grass will be sustained with supplemental macro nutrients, micro nutrients and water such that their carbohydrate production levels, utilization and production of plant enzymes, respiration and biochemical reactions during photosynthesis remain in physiological equilibrium. Basically, healthy turf depends upon plant physiology, and plant physiological reactions can be very specific among different plant species, cultivars within the species and their tolerance to biotic and abiotic stresses.

The critical concentration for each nutrient is defined as the concentration level in the plant tissue at which the plant achieves 90% of its maximum growth. The successful ITHM is therefore based on the science of the turf grass, plant genetic characteristics, and soil and tissue analyses for each cultivar used within the golf course (tees, greens, fairways and roughs).

Although many "organic" products are available for turf management, our turf management team depends upon science to evaluate the most suitable materials and cultural practices for yielding the best results, while minimizing environmental impact. This does not exclude "organic" based products, however some "organic" products such as weed control herbicides made from pepper juice are non-selective and kill the weed as well as the grass.

For the IPM it is imperative to establish what level of damage or organism population size is acceptable before actions are implemented. For example, are 10-20 dandelions per hole acceptable if located in the rough? Likely this would go unnoticed. How about 10-20 dandelions on the putting surface?

The applicants have direct access to the recognized turf management experts from Cornell University, Pennsylvania State University (PSU), University of Massachusetts (UMASS) Amherst, Center of Agriculture Plant Diagnostic Lab for providing analysis, identification and ecologically sound management strategies for diseases, insects, weeds and nematodes found in turf and ornamentals.

ITHM will begin with an independent and objective soils analysis likely conducted by Brookside Laboratories, Inc., New Knoxville, OH considered among the finest agricultural testing labs in the country and recognized for their science based linkage of existing soil chemistries with turf plant health. Brookside will be sent soil samples from areas of the site proposed for fairways, tees and greens and conduct an analysis and audit of soil conditions.

Once the background soil analyses are determined, the applicants will assess the results with respect to turf selection. The NTEP reports will be used in conjunction with university field trials (Rutgers, Penn State, U Mass and URI) to evaluate the selection of turfgrasses most adapted to the local environment.

NTEP is designed to develop and coordinate uniform evaluation trials of turfgrass varieties and promising selections in the United States and Canada. Test results can be used by national companies and plant breeders to determine the broad picture of the adaptation of a cultivar. Results can also be used to determine if a cultivar is well adapted to a local area or level of turf maintenance.

While the IPM approach often includes use of cultural practices to improve the hardiness and sustainability of the plants, the emphasis is still on pest management. For the Hill’s golf course a healthy plant system will be developed that generally resists invasion by weeds, is more resistant to disease attack, is better able to withstand insect attack, and can better recover from extreme weather conditions (i.e., drought, heat, and cold). The current thinking is embodied in the idea of Plant Health Care (PHC), or in our case ITHM.

IPM is still a necessary component of turf management and the Hills will continue to utilize IPM in accordance with management practices required by NYSDEC Pesticide Certification requirements for turf and ornamentals, the NYSBMP and the ITHMP.

The G&SWMP will provide long term post construction water quality information that can be used to adjust onsite management of turf and ornamental plantings.

Bibliography

Agency for Toxic Substances and Disease Registry, United States Department of Health & Human Services, "ATSDR Case Studies in Environmental Medicine Nitrate/Nitrite Toxicity," Retrieved Jan. 26, 2014 from the worldwide web at United States Center for Disease Control. www.atsdr.cdc.gov.

Boehm, M., Rimelspach, J., Hicks, T. (Mar. 2011). "Management of Turf Diseases," Ohio State University-Extension Bulletin, L-187.

Brady, N., Weil, R, (2010). Elements of the Nature and Properties of Soils, 3rd Ed., Upper Saddle River, NJ, Prentice Hall.

Camberato, J., Liu, H., Godwin, S. (July-August 2004). "Tissue Testing for Turfgrass," Clemson University, Turfgrass Program, Retrieved from the worldwide web on Feb. 01, 2014 at www.clemson.edu/turfornamental.

Carrow, R.N, Waddington, D. V. Rieke, R.E. (2001). Turfgrass Soil Fertility and Chemical Programs, Hoboken, NJ, John Wiley & Sons.

Casarett & Doull. (1991). Toxicology, The Basics of Poisons, Elmsford, NY. Pergamon Press Inc.

Chu, A. (2006). "Hydrology of the Lloyd Aquifer on Long Island, New York-A Brief Summary of USGS Investigations," Coram, New York, USGS.

Clancy, K., "Turfgrass Tissue Analysis," Fusion Turf Nutrition, Retrieved from the worldwide web on Jan 12, 2014 at www.ken@fusionfert.com .

Corbitt, R. (1990). Standard Handbook of Environmental Engineering, NY, McGraw-Hill.

Di Napoli, T. (October 2012). Agriculture in Long Island, NYS Comptroller Report 10-2103

Frank, K, & Horgan, B. (Feb. 03, 2014). "Cool Season Turfgrass Nutrition, Fertilizers and Programing" 8-hour seminar, GCSAA, Golf Industry Show, Orlando, FL.

Gelernter, W. & Stowell, L., "Turfgrass Tissue Testing: Pros and Cons," Pace Consulting, San Diego, CA Retrieved Jan. 14, 2014, from the worldwide web at www.paceturf.org.

Gobler, C., "Is There a Connection Between Groundwater Seepage and Brown Tide Blooms in Long Island Embayments?," Natural Science Division, Southampton College, NY. Retrieved Jan. 15, 2014 from the worldwide web at cgobler@southampton.liu.edu.

Golf Digest, *2013-14 Ranking: America's 100 Greatest Golf Courses*. Retrieved Jan. 24, 2014 from the worldwide web at www.golfdigest.com.

Hurdzan, Michael, (1996). Golf Course Architecture, Design, Construction & Restoration. Chelsea, MI, Sleeping Bear Press.

Kenna, M and Snow, J., "The U.S. Golf Association Turfgrass and Environmental Research Program Overview," Research Office, USGA Green Section.

Long Island Groundwater "Proceedings of the Conference on Water Quality on Long Island" Sponsored by The Center for Regional Policy Studies and the Long Island Regional Planning Board held at the State University of New York at Stony Brook, January 26, 1993.

Mattson, N., Leatherwood, R. Peters, C. (Jun 2009). "Nitrogen: All Forms are Not Equal," Cornell University, Cooperative Extension, reprinted from June 2009 Edition of GMPro magazine.

Murphy, J. "Tissue Testing: A Tool for Turf Fertilization," Rutgers University, New Brunswick, NJ.

NYSDEC. (1993). Reducing the Impacts of Stormwater Runoff from New Development, Syracuse, NY, Empire State Chapter Soil and Water Conservation Society.

Pare', K. Chantigny, M., Carey, K. & Dionne, J. (2008). "Leaching of Mineralized Organic Nitrogen from Putting Green Profiles Supporting Various Turfgrasses," Crop Sci. 48:2010–2016 doi: 10.2135/cropsci2007.09.0495c Crop Science Society of America 677 S. Segoe Rd., Madison, WI 53711 USA.

Petrovic, A. "Nutrient Leaching Concerns in Turf Management," Cornell University, Ithaca, NY.

Portman, R. Petrovic, A. (Jan. 29, 2011). "Suffolk County Nitrogen Management Summary Report". Cornell University, Ithaca, NY.

Portmess, R., Grant, J., Jordan, B. M. Petrovic, M., Rossi,F.(Feb. 2014) New York State Best Management Practices for Golf Courses, Department of Horticulture, Cornell University, Ithaca, NY.

Primi, P, Surgan, M, Urban, T. (Summer 1994). "Leaching Potential of Turf Care Pesticides: A Case Study of Long Island Courses." GWMR.

Rossi, F., and Grant, J. (2009). "Long Term Evaluation of Reduced Chemical Pesticide Management of Golf Course Putting Turf," Cornell University, Department of Horticulture, Ithaca, NY. International Turfgrass Society, Research Journal Vol. 11.

Salvato, J. (1992).Environmental Engineering and Sanitation, 4th Ed., NY, John Wiley & Sons, Inc.

Schumann, G., Vittum, P, Elliot, M. Cobb, P. (1998). IPM Handbook for Golf Courses, Ann., Chelsea, MI Arbor Press, Inc.

Snyder, G. and Cisar, J, (1999). "Monitoring Vadose-Zone Soil Water for Reducing Nitrogen Leaching on Golf Courses", 2000 American Chemical Society publication dated December 29, 1999, Retrieved Jan. 22, 2014 from the worldwide web at Pennsylvania State University, http://pubs.acs.org

USGA & Rutgers, The State University of New Jersey. (1990). "Reviewing Golf Course Proposals, Materials for Local Officials," PG 1718, Far Hills, USGA Publications.

Town of Southampton, DEIS The Bayberry Project, (Sebonack Golf Club), Office of the Town Clerk, Southampton, NY.

Town of Southampton, DEIS Golf at the Bridge, Office of the Town Clerk, Southampton, NY.

Turgeon, A, J. (2012). Turfgrass Management, 9th Ed., pp 185- 228. Upper Saddle River, NJ, Pearson Prentice Hall.

Turgeon, A., Vargas, J. (2006). The Turf Problem Solver, Case Studies and Solutions for Environmental, Cultural, and Pest Problems, Hoboken, NJ, John Wiley & Sons, Inc.

USEPA. Ground Water Contamination and Methodology, Lancaster, PA, Techomic Publishing Co.

Vargas, J., (2005). Management of Turfgrass Diseases, 3rd Ed., Hoboken, NJ, John Wiley & Sons.

USDA (1975). Soil Survey, Suffolk County, New York.

US Department of Agriculture 2007 US Census Bureau of Agriculture, 2007 Suffolk County, New York Retrieved Jan. 21, 2013 from the worldwide web: www.Agcensus.usda.gov.

Wolkowski, R. P., Kelling K. A., Bundy, L. G., "Nitrogen Management on Sandy Soils," A3634 Wisconsin Cooperative Extension Publications, Madison WI. Retrieved from the worldwide web on Feb. 13, 2014: www.golfcourseindustry.com ,Golf Course Industry. Richfield, OH. GEI Media Inc.